POWER

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Wanted, Two Names

LEADERS of American boiler practice are adopting the absorption of 1,000 B.t.u. as the unit of evaporation instead of the heat of evaporation from and at 212 degrees F.

As yet this unit has no name. It is referred to as the "unit of evaporation."

A pound is a unit of weight, but one does not go to the grocer and ask for so many "units of weight" of sugar. The unit of weight in which he buys sugar has a name —the pound.

It would popularize the unit of evaporation if it had an appropriate and acceptable name, if one could say that a boiler that had evaporated so many pounds of feed water of a given temperature into steam of a given pressure and quality had done so many ——s. Another performance reduced to the same units would be comparable.

When James Watt sold a pumping outfit, he sold the capacity to do a given number of foot-pounds per minute. He needed a unit of foot-pounds per minute, a unit of power, and he adopted the horsepower as that unit.

The outfit, comprising originally the boiler as well as the engine, has become split up. The term "horsepower" is retained as the unit of engine capacity. The manufacturer of the detached boiler sells evaporative capacity, and he needs a unit for that capacity that will mean units of evaporation per unit of time.

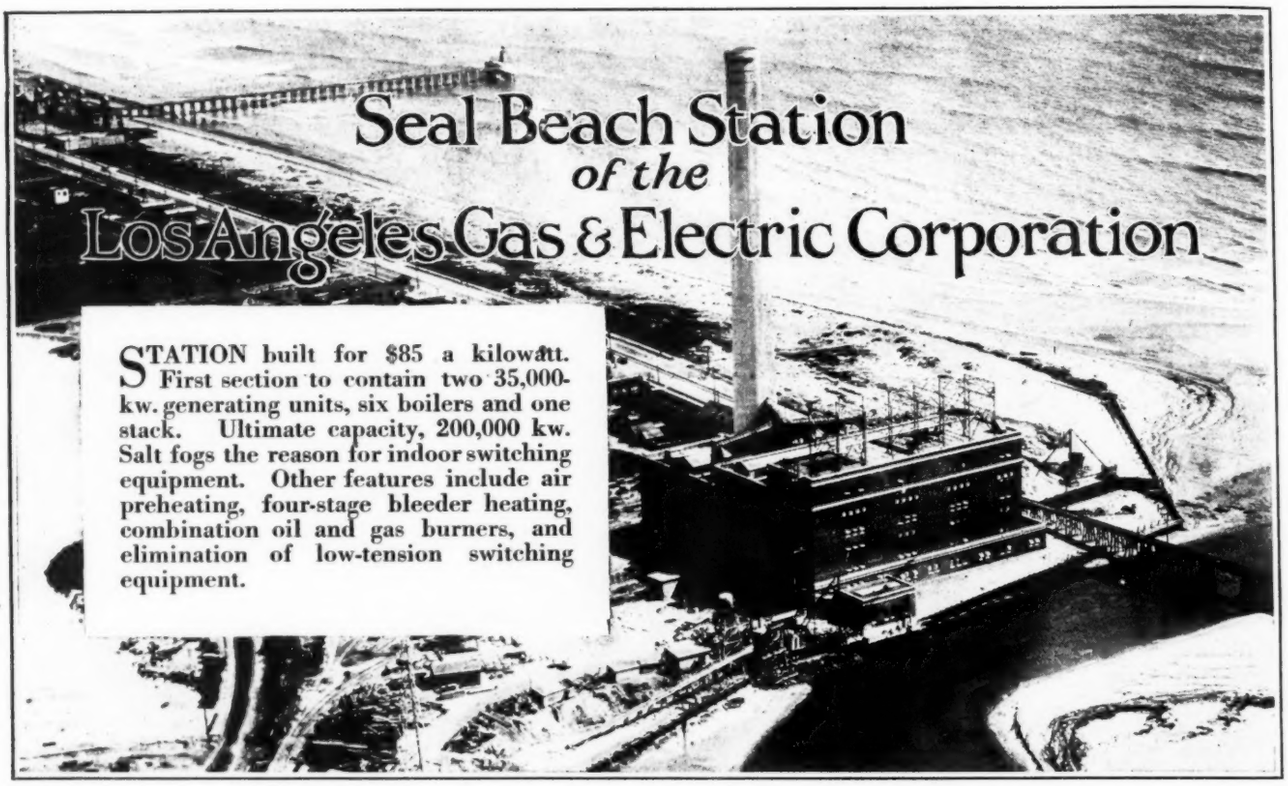
Why not make the unit of capacity one unit of evaporation per minute, one —— equals one —— per minute, and then find suitable names for the unit of evaporation and the unit of capacity?

One —— would equal something over two boiler horsepower.

Instead of saying that a boiler had a capacity of so many horsepower, we would say that it had a capacity of so many ——s, and to find the number of ——s we would divide the number of B.t.u. that it absorbed per minute by 1,000 instead of the number that it absorbed per hour by 33,479.

We have to reduce the performance to B.t.u. absorbed per unit of time now to get the horsepower as a measure of capacity.

The term horsepower is used in another sense in connection with boilers as indicating their size, ten square feet of heating surface being allowed per horsepower. This will probably persist as a trade usage especially as applied to small boilers of standard design and setting, but heating surface is becoming of less significance as a measure of capacity. The intensive methods of firing that are being developed and the modification of design so as to put a larger proportion of the heating surface where it can "see" the fire and absorb radiant heat are making it possible to evaporate more than the once usual "about three" pounds of water from each square foot.



Seal Beach Station of the Los Angeles Gas & Electric Corporation

STATION built for $85 a kilowatt. First section to contain two 35,000-kw. generating units, six boilers and one stack. Ultimate capacity, 200,000 kw. Salt fogs the reason for indoor switching equipment. Other features include air preheating, four-stage bleeder heating, combination oil and gas burners, and elimination of low-tension switching equipment.

THE building for the first 70,000-kw. section of the Seal Beach (California) Station is now finished, with one 35,000-kw. unit installed. In 1923 the rapid growth of the load led the Los Angeles Gas & Electric Corporation to lay plans for a new station supplementing the Alameda Street plant, which is in the heart of Los Angeles. While cooling towers were used at Alameda Street, they were considered impracticable for the much larger station that would be needed to carry the growing load. This and the high cost of a satisfactory location in Los Angeles necessitated the selection of a site on the Pacific shore.

Owing to the topography of the shore, existing ocean-front property developments and adverse water conditions, suitable power-station sites are very limited. The Seal Beach site, finally selected, is on Alamitos Bay about thirty miles south of Los Angeles. The inlet formed by the mouth of San Gabriel River at this point made possible the location of a plant with a circulating-water inlet on one side and an outlet on another, thus insuring against any appreciable recirculation of the condensing water. Incidentally, the hard-packed subsoil made the location as good as any along that part of the coast for foundation construction.

The size of the generating units (35,000 kw.[1]) was fixed as the largest warranted by the estimated growth of the load. The use of larger units would have involved an undue period of operation at low load factor and corresponding low efficiency after the installation of each new unit.

Similarly, the building-section size of 70,000 kw. was arrived at on a basis of a balance between the overhead cost of idle space while waiting for the load to grow, and the reduced cost per generating unit of constructing building sections to house more generating capacity. Another consideration in locating the plant was the availability of oil and natural gas through pipe lines running close to the property and affording a double supply of fuel. As with most plants built on the sectional plan, the ultimate capacity is more or less conjectural, but the figure of 200,000 kw. is a reasonable prediction.

Space is lacking for a detailed description of the station, so this article will be confined to a brief outline of its main features, followed by a discussion of certain points of particular engineering interest.

At present three 25,450-sq.ft. water-tube boilers of the cross-drum type are installed. Fired with oil and natural gas, they will be capable of continuous operation at 200 per cent rating, with steam at 375-lb. pressure and 700 deg. F. The present building has space for six such boilers. Connected with each boiler is a 23,025-sq.ft. air preheater of the tubular, three-pass type.

Draft is provided by forced-draft fans, one to a boiler, driven by 440-volt induction motors, with brush-shifting control, and by concrete stacks superimposed on the building steelwork. The first concrete stack, which will handle the first 70,000 kw., is now complete. The stacks have an inside diameter of 23 ft. and rise 375 ft. above the boiler-room floor.

Three centrifugal boiler-feed pumps are now installed, one turbine-driven and two motor-driven. Seal Beach will normally be started up from cold by current from the Alameda station, but the turbine-driven feed pump is provided for emergency use. A similar arrangement is made for excitation.

The feed water is heated in four stages, in a manner to be described more fully later. Two single-effect evaporators of the submerged-tube type are now installed, each with a capacity of 7,500 lb. of distilled water per hour.

The main generating units have a capacity of 35,000

[1] As will be explained more fully later, this unit was purchased for 30,000 kw., but has proved capable of continuous safe operation at 35,000 kw.

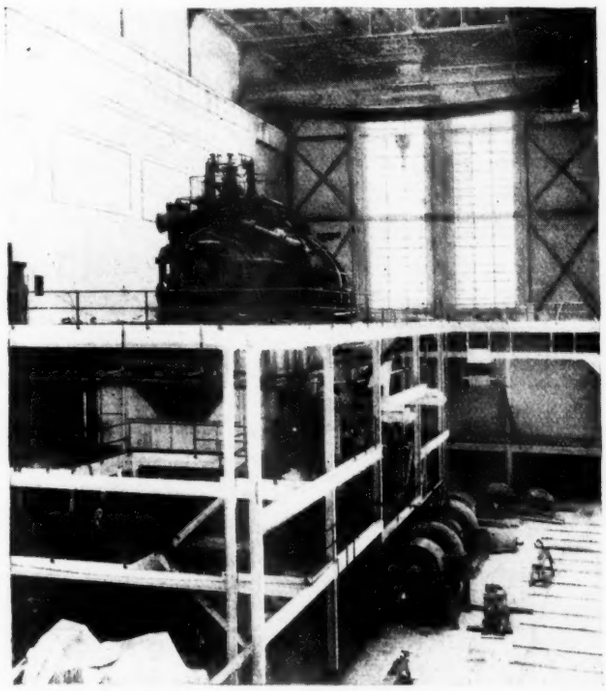
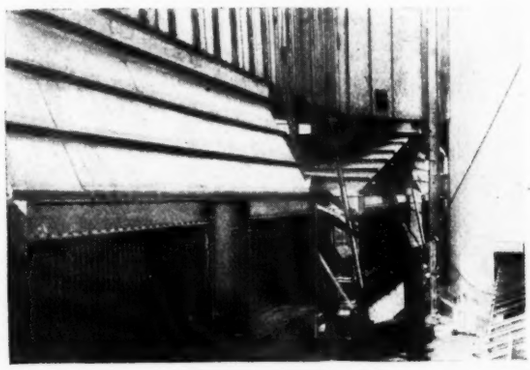


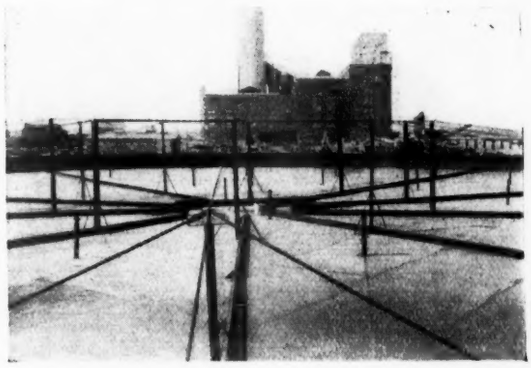
Fig. 1 (Right)—View of turbine room showing one 35,000-kw. unit with condenser and circulating pumps

Note open construction and placing of turbine on one side of the room, leaving ample space on the basement floor for storage of turbine parts during dismantling operations.

Fig. 2 (Below)—Air inlets of preheaters. Location of preheaters and breeching on the roof resulted in considerable saving in building cost

Picture taken during the construction. When finished, tubes shown within air inlet will be protected from the weather.





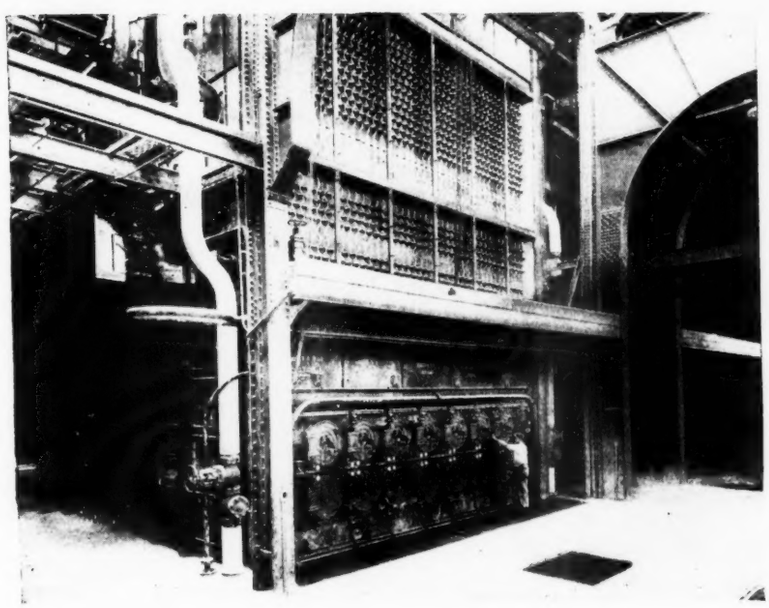


Fig. 3 (Above)—Floating top of oil-storage tank is designed to prevent evaporation and fires

Fig. 4 (Left)—Boiler front, showing combination burners for oil or natural gas

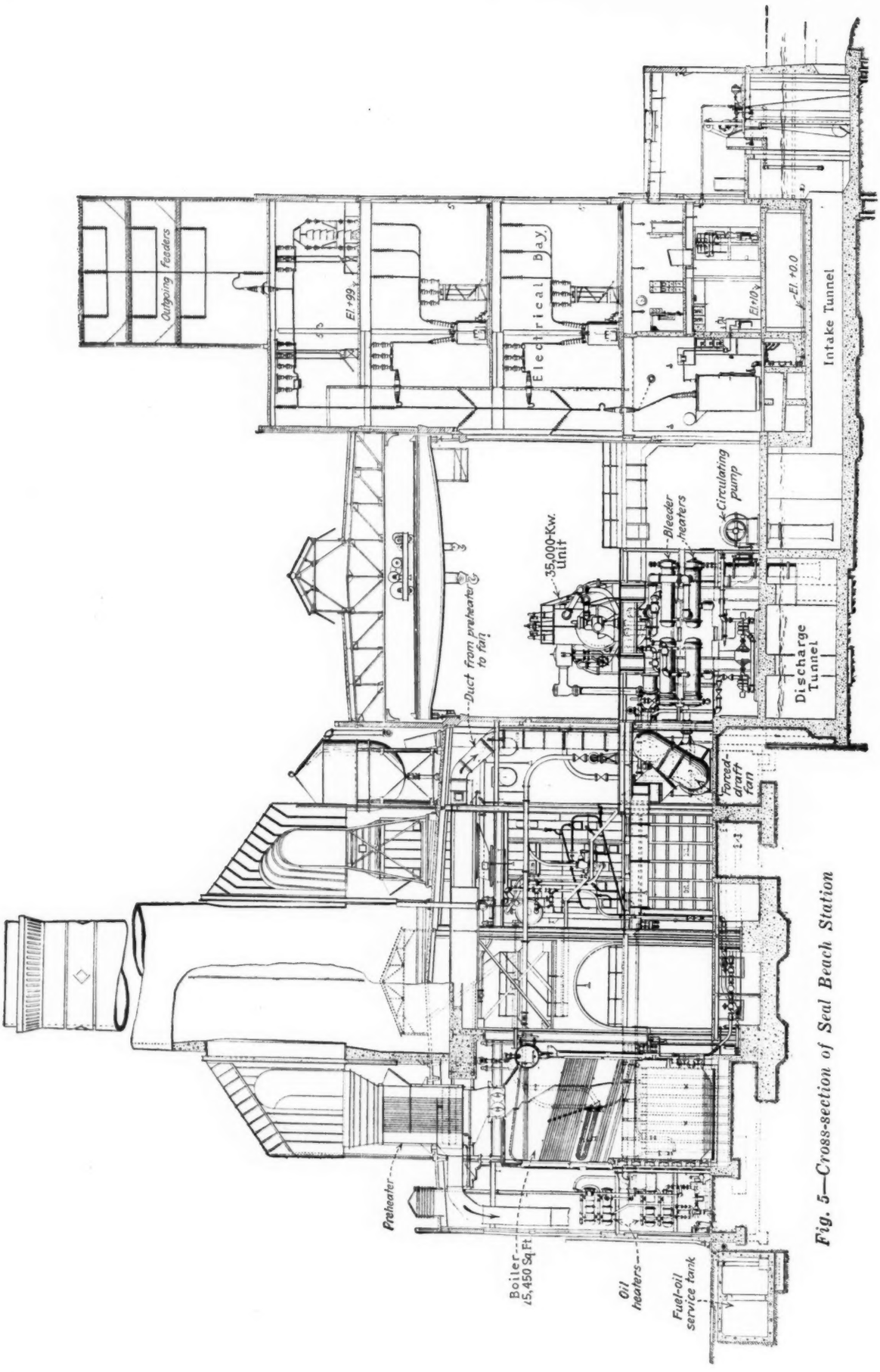


Fig. 5—Cross-section of Seal Beach Station

kw. each at 80 per cent power factor, and are three-phase 60-cycle 13,200-volt machines. The guaranteed steam rates with no bled steam, with throttle steam at 350 lb. gage and 264 deg. superheat, and with a 29-in. vacuum, are as follows:

Load, kw.	Lb. Steam per Kw.-Hr.
15,000	10.23
22,500	9.62
26,250	9.44
30,000	9.49
31,250	9.50
35,000	9.64

The turbine blading consists of two impulse rows, nineteen reaction rows and six Bauman rows, the last-

local distribution by a substation close to the load center.

While oil is the principal fuel used in the steam-power plants of southern California, natural gas is a secondary fuel of considerable importance. At Seal Beach pipe lines direct from the producing fields provide supplies of both gas and oil. To permit the use of either of these fuels without unnecessary duplication of equipment, the furnaces are fitted with combination oil and gas burners. In these air is admitted through an annular opening between the gas ring on the outside and the oil atomizer in the center. A feature of the fuel-oil system is the floating top provided for the

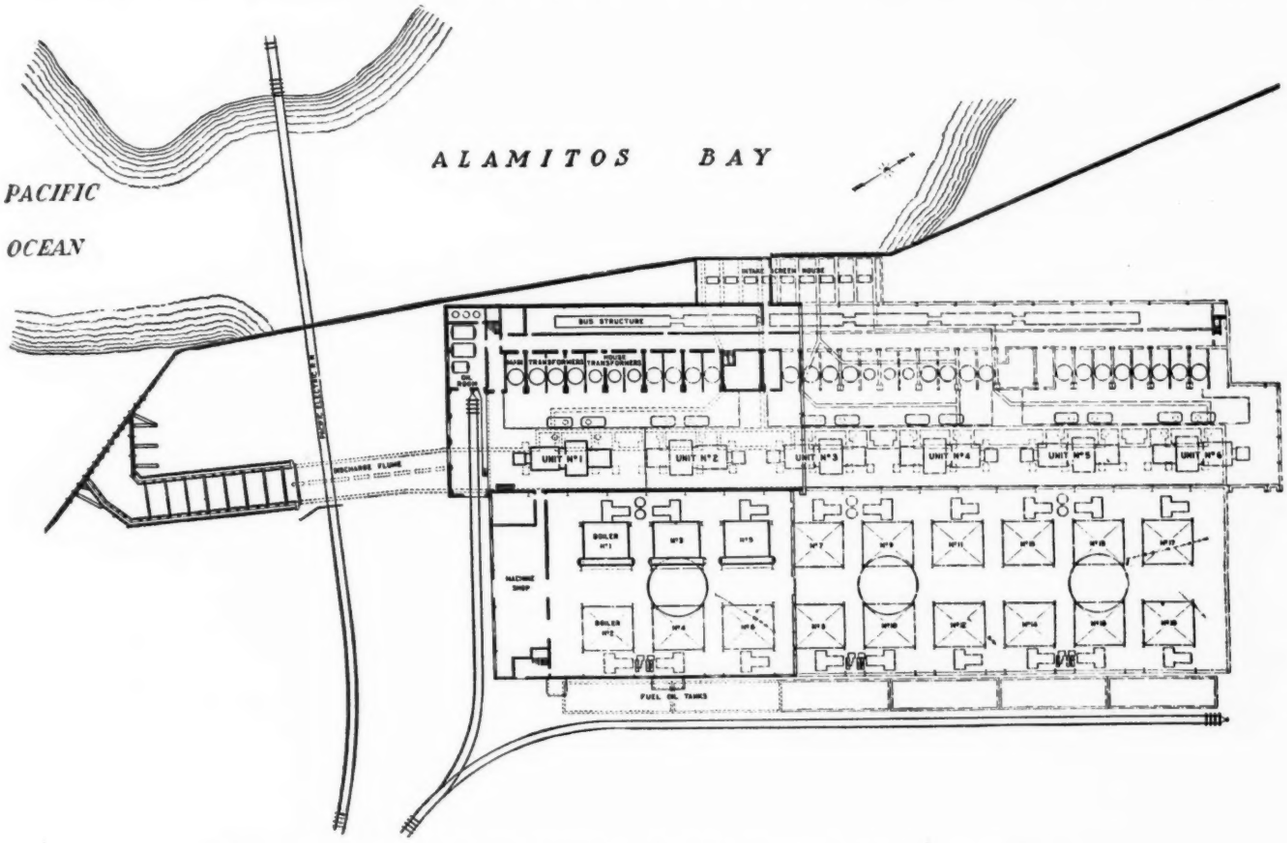


***Fig. 6**—Plan of station and property, showing provision for future extension*

named design permitting the use of shorter blades at the low-pressure end of the turbine and making double-flow or two-cylinder design unnecessary. No house turbines are used, electric drive for auxiliaries being supplied in part from auxiliary generators on the main-unit shafts.

Each main turbine exhausts into a 45,000-sq.ft., two-pass surface condenser provided with two 25,000-gal.-per-min. circulating pumps driven by 2,200-volt wound-rotor induction motors. Air is removed from each condenser by two steam-jet two-stage vacuum pumps with intercoolers and after-condensers.

The Seal Beach Station is equipped with water meters, steam meters, gas meters, CO_2 recorders, draft gages, and the usual indicating thermometers, recording thermometers and gages. In addition, concentration meters are provided to detect condenser leakage.

The entire output of the plant will be transmitted at 110,000 volts over a 25-mile steel tower line to Los Angeles, where the voltage will be stepped down for

main storage tank, which eliminates the possibility of serious tank fires.

In these days of rapidly mounting steam pressures and temperatures it is always of interest to know why any particular pressure or temperature was chosen. As is well known, efficiency rises steadily with both pressure and temperature. The corresponding cost of equipment does not rise steadily, but by steps. Practically the same equipment is required for 200 lb. and 600 deg. as for considerably higher pressures and temperatures. But when conditions approximating 400 lb. and 725 deg. are reached, new types of design begin to enter. Boilers and piping must be heavier. Special materials and more costly construction must be used for valves and for the higher stages of turbines. With these comes the element of uncertainty normally associated with relatively new types of construction.

Reasoning along this line, and taking into consideration the fact that the intended operation of Seal Beach as a base-load station imposes the dual requirement of

high efficiency and the utmost reliability, the engineers decided upon 350 lb. and 700 deg. as being the highest throttle conditions warranted on a conservative basis.

Much attention was given to methods of securing high efficiency without undue complication, enhance-

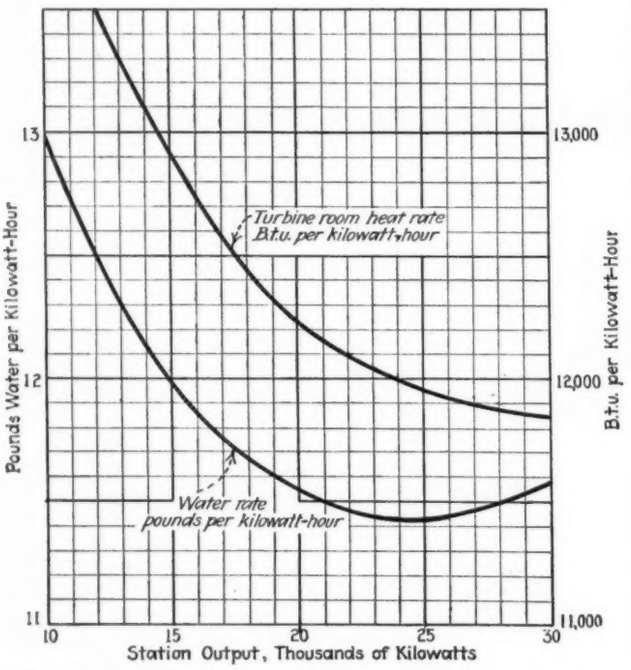


Fig. 7—Predicted turbine-room heat and water rates.

ment of cost or sacrifice of reliability. The success attained may be judged by the total cost of $85 per kilowatt when the two-unit station is completed, based on the actual capacity of the machines, namely, 35,000 kw. at 80-percent load factor. Tests have shown this rating to be conservative, although the machine was bought for 30,000 kw. This cost corresponds to $100 per kilowatt on the latter rating. Even with this low cost a station heat rate of 15,000 B.t.u. per kilowatt-hour is anticipated.

The design of this plant is predicated upon an economical use of ground area coupled with the provision of ample working space around all the apparatus. The accompanying table shows a total station ground area of 0.650 sq.ft., and a station volume of 52.6 cu.ft., per kilowatt of installed capacity.

While no general rule can be laid down for attaining low floor space and cubical content per kilowatt, the general plan of attack in the Seal Beach design may be outlined. The basis of the design was a power-generation unit consisting of two boilers, one turbo-generator and one transformer. With six boilers for two turbines at least two boilers can be considered as spares even at peak loads. The boiler-room arrangement shown in Figs. 5 and 6 with one central firing aisle, conserves floor space and volume. For units of the dimensions here used, arrangement of the turbo-generators, end to end, with their shafts parallel to the boiler room, keeps down the size of the turbine room,[2] while a considerable saving in space, complication and first cost is obtained by eliminating all switching equipment between the generators and the step-up transformers (except one synchronizing switch), which raise the generated voltage of 13,200 to 110,000 volts for transmission to Los Angeles. In the opinion of the designers electrical equipment has reached a state of development where such a design of switching equipment at transmission voltage meets all practical requirements for a plant of this type.

While on the subject of electrical equipment the question may be raised as to why Seal Beach, in the face of the growing use of outdoor switching yards, houses all its switching equipment within the building. The answer is found in the salt fogs that hang over this part of the California coast practically twelve months in the year. In other coast plants fog has caused trouble by electrical leakage and the resultant short-circuits.

One of the major problems in the design of this station was the selection of a heat cycle to give the highest commercial efficiency, that is, the lowest overall operating cost (including interest and depreciation) consistent with reliability. The possible combinations were infinite, but it was certain in advance that several stages of bleeding would be used. The practical choice lay between three and four stages. This matter could not be decided by itself, but only in connection with the method (if any) of recovering flue heat. A detailed comparison was made, taking as a standard a plant burning oil, with four stages of bleeding and no reclamation of flue heat.

The comparative results, all reduced to a basis of total

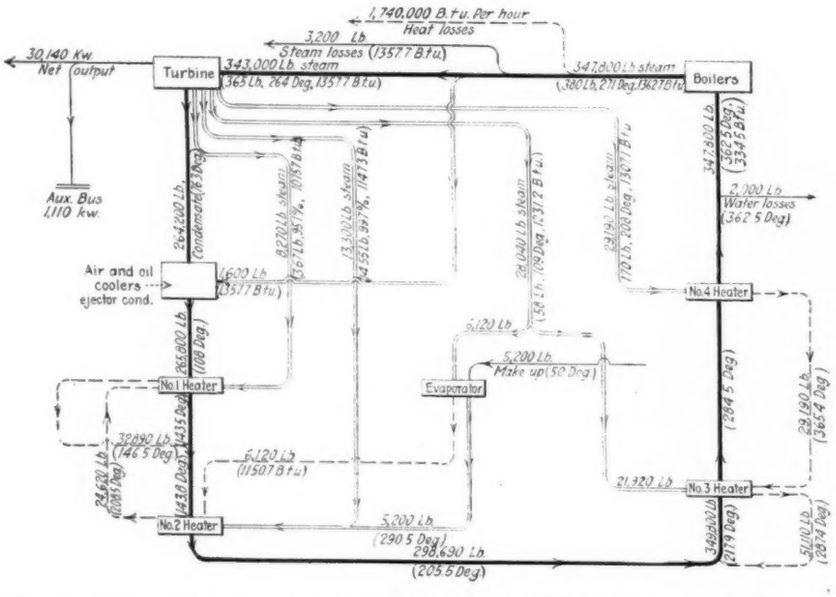

1,740,000 B.t.u. Per hour Heat losses
3,200 Lb Steam losses (1357.7 B.t.u.)
30,140 Kw. Net output
Turbine
343,000 Lb. steam (365 Lb. 264 Deg. 1357.7 B.t.u.)
347,800 Lb steam (380 Lb. 271 Deg. 1362.7 B.t.u.)
Boilers
Aux. Bus 1,110 kw.
Air and oil coolers ejector cond.
No.1 Heater
No.2 Heater
No.3 Heater
No.4 Heater
Evaporator
5,200 Lb. Make up (50 Deg.)
2,700 Lb Water losses (362.5 Deg.)

Fig. 8—Predicted heat balance based on output of 30,140 kw. per unit

yearly operating cost, are shown in Fig. 9. For oil costing less than $1.25 per barrel the standard chosen proved commercially more efficient than any other arrangement, except a similar arrangement with six boilers

[2] Incidentally, the location of generating units on one side of the turbine room leaves ample space for storage of turbine parts during dismantling operations.

per stack. With more expensive oil the addition of an air heater improved the commercial efficiency, with a slight additional gain when six boilers were used per stack instead of three. This was for a stack temperature of 350 deg.

The study showed that the recovery of more flue heat by the use of larger air heaters, designed to reduce the

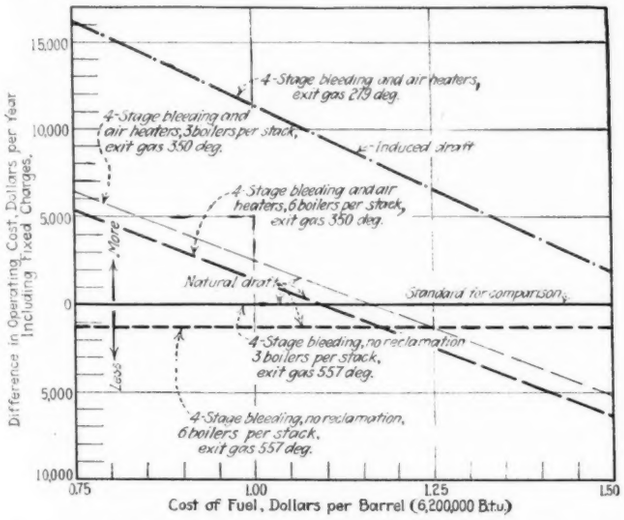

15,000
10,000
5,000
0
5,000
10,000
Difference in Operating Cost, Dollars per Year Including Fixed Charges.
4-Stage bleeding and air heaters, exit gas 279 deg.
4-Stage bleeding and 1 air heaters, 3 boilers per stack, exit gas 350 deg.
Induced draft
4-Stage bleeding and air heaters, 6 boilers per stack, exit gas 350 deg.
More
Natural draft
Standard for comparison
4-Stage bleeding, no reclamation 3 boilers per stack, exit gas 557 deg.
Less
4-Stage bleeding, no reclamation, 6 boilers per stack, exit gas 557 deg.
0.75
1.00
1.25
1.50
Cost of Fuel, Dollars per Barrel (6,200,000 Btu)

Fig. 9—Study made to determine method of heat reclamation, number of boilers per stack, etc. Based on predicted load for 1925

flue temperature to 279 deg., would not pay, owing to the more expensive preheaters and the necessity of using induced-draft equipment.

Various other heat-recovery combinations were evaluated, but the air heater showed a better commercial economy for the conditions existing at the Seal Beach Station.

The selection made was based on the prediction that

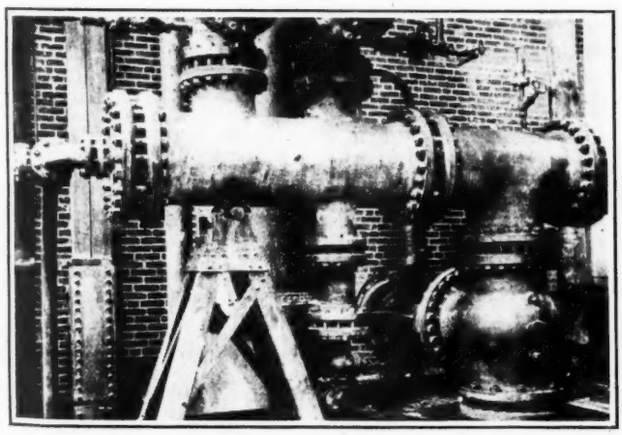


Fig. 10—Sargol weld-sealed joints, typical of the high-pressure lines

the price of oil would average $1.25 per barrel or more throughout the life of the plant.

The heat-balance flow diagram of the Seal Beach Station is shown in Fig. 8, the four bleeder heaters being numbered in order of ascending temperatures. As usual, the low-temperature heat from generator-air and oil coolers and air-ejector condensers is absorbed by the feed water before it passes to No. 1 bleeder heater.

"Bridging" of the evaporator from the third bleed point to the second heater was fixed by three considerations, as follows: The temperature drop should be a minimum to avoid unnecessary loss of "heat head"; the evaporator should operate under a low pressure for mechanical reasons; it should not operate under vacuum.

The heat balance used is substantially the same as that which has worked out exceptionally well, both as to station efficiency, first cost and operating simplicity, at the Colfax Station.

While the generator air is normally cooled by condensate from the main units, additional salt-water

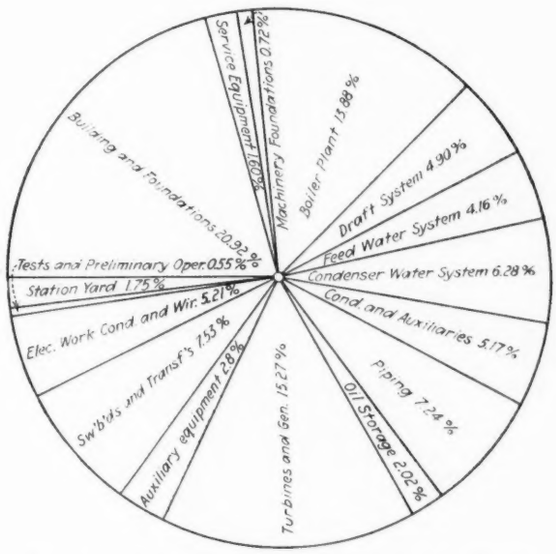


Fig. 11—Cost diagram of Seal Beach Station

coolers, independently operated, are provided as a safeguard against generator overheating.

The boiler and furnace design is standard except for two unusual features. To improve water circulation in the boiler an extra row of tubes has been added at the top, as may be seen from the plant cross-section (Fig. 5). The same drawing shows a new type of air-cooled furnace wall in which cast-iron boxes replace the usual double brick wall.

DATA ON FLOOR SPACE AND VOLUME

(Based on completed first 70,000 kw. section with 6 boilers containing a total of 152,700 sq.ft. of heating surface)

Part	Floor Space	Sq.Ft. per Sq.Ft. Surface	Sq.Ft. per Installed Kw.
Boiler house ..	20,800	0.136	0.297
Turbine room ..	13,500	0.088	0.193
Electrical bay .	11,200	0.074	0.160
Total	45,500	0.298	0.650

Part	Cu.Ft. of Building	Cu.Ft. per Sq.Ft. of Boiler Surface	Cu.Ft. per Installed Kw.
Boiler house ..	1,206,400	7.90	17.2
Turbine room ..	1,249,560	8.19	17.9
Electrical bay .	1,224,288	8.01	17.5
Total	3,680,248	24.10	52.6

This project has been directed by A. B. Day, vice-president and general manager of the Los Angeles Gas & Electric Corporation, assisted by H. J. Kister, manager of operation and construction and J. G. Rollow, electrical engineer. Dwight P. Robinson & Co., Inc., acting as agents, have executed the design and construction of the power station, the transmission lines and the substation connected therewith.

Some Considerations on Solid Injection for High Speed Engines

By ROBERTSON MATTHEWS

ONE of the stock criticisms presented in the discussion on the limitations of the high-speed oil engine, is the difficulty of metering small quantities of fuel. The operation of small engines on solid injection at 1,200 r.p.m. and above, now on record, is an achievement that should soon remove that criticism.

The injection pumps on these high-speed engines meter quantities equal to the volume of spheres ⅛ in. in diameter and under. With injection plungers having these small displacements and operated with 2,400 to 3,600 reversals of motion in one minute, the injection pump cannot be expected to lift the fuel, nor can accurate, uniform metering be expected if the pump is allowed to have a variable amount of slip. Beyond some moderate r.p.m. the ordinary plunger pump may

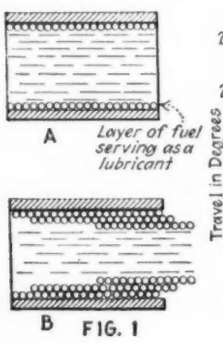


Fig. 1 — Shearing action of oil

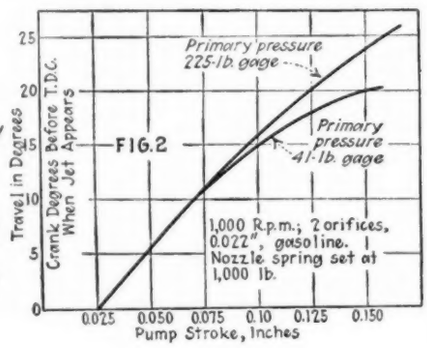


Fig. 2—Lag in the oil spray with change in timing

be expected to have its slip increase with the r.p.m. This will be due to port resistance and valve action, and since the heavier liquid fuels have viscosities that vary considerably with the grade of fuel and temperature, the slip of a simple injection pump can be expected to vary also with the fuel "drag" corresponding to the kind, grade and temperature of the fuel. No injection pump can be expected, however, to meter accurately when its cavity holds an unknown amount of fuel. Hence, elimination of slip is highly desirable in the high-speed injection system.

The most ready means of attempting to eliminate slip seems to be to supply the injection and metering pump with fuel already under considerable pressure. This pressure can be provided either by another pump together with a relief valve or by gas pressure above the fuel. This latter method, however, not only requires mechanism to supply and control the gas pressure, but can interfere with accurate metering. It is not satisfactory to attempt to meter a fuel stream interspersed with irregular quantities of air or other gas. Liquids absorb increasing amounts of gas as the gas pressure over the liquid is increased, and when the pressure on the oil is reduced some of this gas will be released. Bubbles and gas pockets are possible consequences.

The use of the primary pump introduces two problems: (1) The pressure necessary; (2) the type of primary pump. The necessary primary pressure depends on the "drag" of the fuel; the size of the connecting lines and pump passages and upon the r.p.m. of the injection pump. One is unable to calculate the pressure to meet these conditions. It is doubtful if any data exist at present that are at all applicable to these conditions in company with intermittent flow and discharge. It is probable that with the rapid changes of flow occurring in these small pump passages, the flow of the fuel takes on characteristics similar to what seem to prevail during the intermittent discharges from small injection orifices. Compared with calculated values, the pressures actually required at high engine r.p.m. to drive the fuel through small orifices, seem much out of proportion to the average velocity of the liquid. Apart from any pressure requirements to create acceleration of the jet, the following tentative explanation of the cause of this seemingly excessive required pressure is offered.

Shear of Oil Layers

In large pipes and nozzles the outer layers of the liquid may be considered serving as a lubricant for the central stream or core, as indicated in Fig. 1-*A*. Now let a violent pressure be exerted on the liquid and the slower moving particles contacting with the walls of the pipe, will cause successive inner layers of liquid to drag upon each other. Thus, instead of only an outermost layer, a second and third layer and so on, counting from outside to center, will drag. Then if the pressure increase be sufficiently violent, a condition as in Fig. 1-*B* will occur.

If the passage is restricted to the extent of the orifices used in solid injection, which have been made as small as 0.012 in. diameter, it seems possible that no core whatever can remain intact and the process becomes one of "telescopic shearing" of a multitude of sleeve-like layers of the liquid. Suppose this explanation is, even in a measure, correct. Then with intermittent flow superimposed as another effect on top of telescopic shearing, evidently coefficients of discharge for continuous flow do not even approach being applicable to the existing conditions in high-speed injection apparatus.

This same explanation, if extended to the penetration of jets from plain orifices, goes some way toward showing the fallacious basis on which some German investigators have tried to present mathematical values for the penetration of such jets. Some of those calculations have been based on the friction between air and rain drops. Now if the center of the jet can telescope through successive layers of its own self, then at what distance from the orifice will the last telescoping occur? The answer involves not only fluid friction, but the shearing strength of the liquid as well as the displacement resistance of the successively diminishing

cross-sections penetrating the compressed air. Anyone who has exposed his hand to one of these high-speed jets from a plain orifice, is inclined to discredit pure mathematics supported by theories evolved from the more leisurely behavior of liquid particles of the size of raindrops.

So far as the eye can be trusted, the existence of a core in jets from plain orifices is substantiated by observations in the open, with an oscilloscope and with illumination from synchronized high-tension sparks in a dark room set-up, showing the jet at different stages of its progress from the orifice.

By "plain orifice" is here meant an orifice up to which the fuel flows through a liberal opening between the valve and its seat. The jet from such a tip must not be confused with that issuing from a single hole after first being restricted in its flow to a thin sheet due to

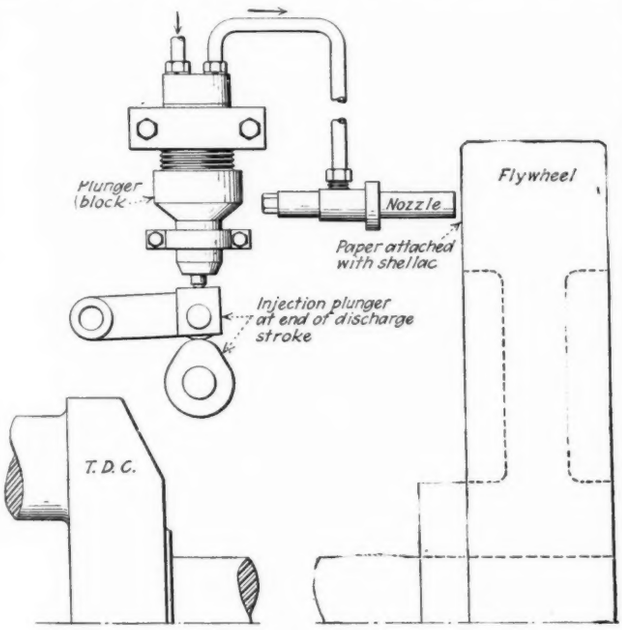


Fig. 3—Apparatus used to determine oil lag

the minute lift of the valve, with possibly some pulverizing within the orifice. A good illustration of this system is the Scott diaphragm type in which the orifice plate springs away from the fixed valve stem instead of having the more customary lift of the stem.

A frequent, serious omission when discussing jet penetration, is a description of the kind of jet under consideration. The impact of the jet from a plain orifice may be unendurable at ten times the distance that the hand may, with impunity, withstand a whirling jet. This is as it should be if the plain orifice nozzle is designed and adjusted to atomize by impact between jet and air.

Since the necessary primary pressure cannot be predetermined, a means will be illustrated for checking whether an existing primary pressure is sufficient to insure accurate and uniform metering. To determine the interval of crank travel during which the pump is discharging, the nozzle may be removed from the cylinder and connected to shoot against paper targets fastened to the side of the flywheel as shown in Fig. 3. The curves of Fig. 2 are from data obtained in that way.

The pump was of the variable-stroke type with a cam-operated plunger. To increase the stroke the plunger block was moved nearer to the cam, causing more of the cam lift to be utilized. The cam was timed, as shown in this sketch, so that the maximum lift, or end of the plunger stroke, occurred just as the engine crank was passing top dead center. Hence, each target showed at what crank position the jet first appeared and also how long injection occurred before the cam reached its peak. These two curves in Fig. 2 are for 1,000 r.p.m. and the same series of different lengths of plunger stroke. The primary pressure was different, being 225 lb. in one case and only 41 lb. in the other. It will be observed that the interval of discharge up to top dead center, as shown by the height of the curve, was the same for both primary pressures, while the stroke was increased from 0.025 up to 0.075 in. With further increase in the length of stroke the jet was later in appearing when the lower primary pressure was used, with a resulting decrease in the interval and in the quantity of discharge. This shows that the lower primary pressure was then insufficient to fill the chamber of the injection pump in the time available, and hence there was appreciable and increasing slip as the stroke was increased beyond 0.075 in.

Unsatisfactory Pump Designs

As a primary pump neither the plunger nor the ordinary type of gear pump is wholly satisfactory. A multi-cylinder engine with an injection plunger for each cylinder requires a multi-plunger primary pump in order to give approximately constant primary pressure or the necessary primary flow when needed. Thus a two-plunger injection pump requires two primary plungers, and a four-plunger injection pump will require at least three primary plungers. Since a plunger is inherently single-acting, one primary plunger to two injection plungers is not a favorable combination at high engine r.p.m. Furthermore, a primary plunger pump must be made with nearly as much care as the injection pump if leakage troubles are to be avoided. Its performance depends on valves and either glands or lapped fits; and it is bulky in proportion to its service.

Gear primary pumps are more compact for the same capacity, but require staging to meet high-pressure conditions, for unless made with a refinement scarcely applicable to ordinary shop production a high r.p.m. is necessary to offset leakage past the gears.

The repeated work upon the fuel that leaks by the gears allows the pump to warm up. To offset this heating effect much more fuel than is needed must be pumped, bypassed and cooled. The result is a pump with an overload on its bearings, yet having theoretically much excess capacity. A spring-loaded packing gland is beneficial under such circumstances, but does not remove the difficulty. It would seem that a bearing flooded with oil should stand up well, but liquid fuels at best are but poor lubricants, and ordinary lubricants, if applied, are washed out by the fuel. Suitable material for these bearings seems hard to find.

Ball bearings might reduce this bearing trouble, but the load would be still greater than on plain bearings and there would be more slip. This is because of the necessary increase in the diameter of the gears to accommodate the greater distance between centers required with ball bearings as compared with plain bearings. If the ball bearings are staggered, other unfavorable design features arise.

New Type of Synchronous Motor for Driving Reciprocating Compressors

By G. M. CHUTE
Industrial Engineering Department, General Electric Company

Motor is provided with special type of pole-face winding to increase starting and pull-in torques. Efficiency has been improved by improvement in air-gap design.

FOR a number of years the definite requirements of compressor drive have been the subject of extensive study and investigation. As a result of these tests the need has been shown for a motor embodying the following characteristics: Extreme simplicity of the starting operation; starting conditions satisfactory to the power company; adequate torques; efficient operation, and minimum flywheel requirements.

To meet these requirements the General Electric Co. has recently placed on the market a new type of synchronous motor, two of which are shown in Figs. 1 and 2. This motor is designed for direct drive of slow-speed reciprocating compressors which have their greatest application in furnishing compressed air, or

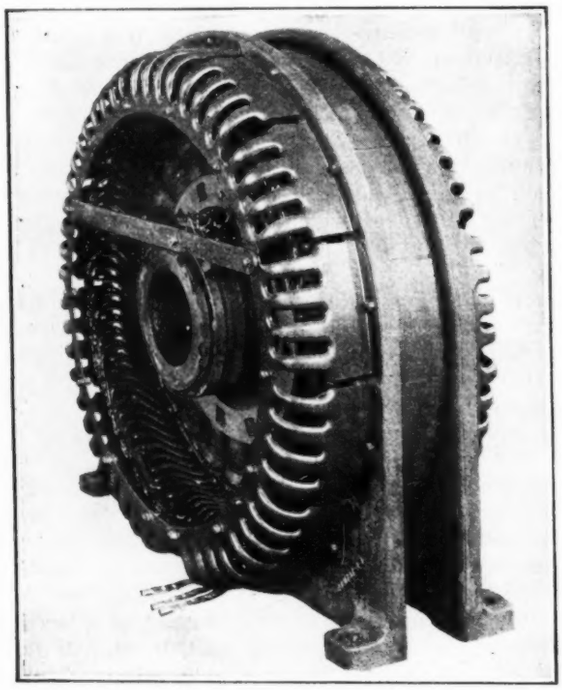


Fig. 1—Motor designed with small diameter for given output

in artificial refrigeration. The complete line is being built in more than 300 standard ratings of 20 hp. and greater, for 60-cycle circuits at speeds between 72 and 450 r.p.m. Owing to the nature of compressor drive, these motors are given a maximum rating at a temperature rise of 50 deg. C.

Electrical equipment has now generally displaced slow-speed steam engines for driving compressors, and today the direct-connected synchronous motor is usually given preference over the belted induction motor for the same service, because of the great saving in floor space and improvement of power factor.

The starting of a synchronous motor has often been considered a delicate operation. The new motor has

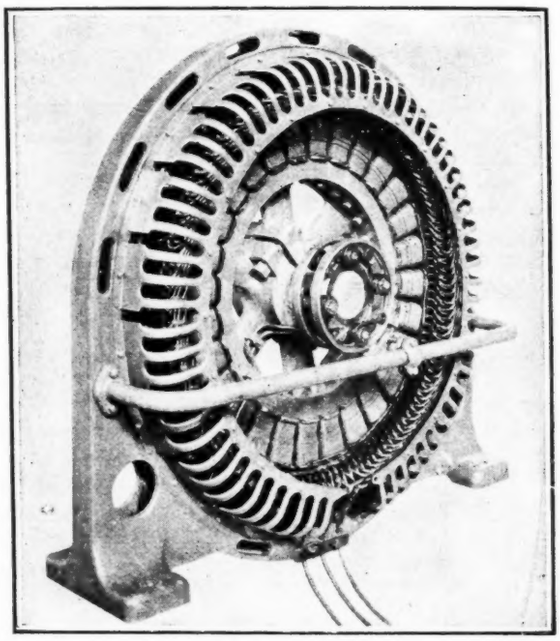


Fig. 2—Motor designed with large diameter for given output

been placed on a more favorable basis than the belted induction motor from the viewpoint of control. This has been accomplished by designing it for starting at full voltage. When started manually, only two switches need be closed to put the motor in operation. The motor field is specially designed for use with automatic devices for applying excitation, thus reducing the starting operation still further to the closing of a single oil switch or the pushing of a button. Full-voltage starting produces no abnormal strains in any part of this motor, neither is any appreciable shock transmitted to the compressor.

Starting on Full Voltage

Although the motor is started at full voltage, the inrush current from the power line is held within limits that are acceptable to practically all power companies. At motor speeds less than 240 r.p.m. the inrush current is guaranteed to be less than 250 per cent of the rated full-load current of the motor. Up to 450 r.p.m. the inrush is guaranteed not to exceed 300 per cent.

These inrushes compare favorably with the starting currents drawn by other types of slow-speed synchronous motors started at reduced voltage.

Perhaps the most important feature of the new design is that, although the starting current has been limited during the starting period to a percentage less than that obtained with the conventional types, the

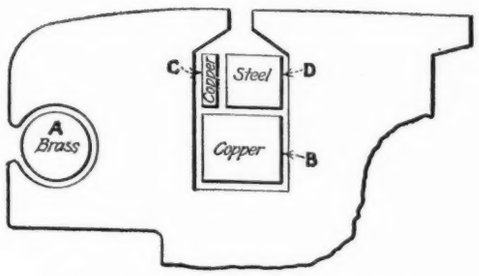


Fig. 3—Arrangement of pole-face windings

available torques are still maintained at values capable of starting any of the standard air or ammonia compressors. These compressors are unloaded during the starting period. Extensive tests and experience have shown that it rarely requires more than 35 per cent of full-load torque to start any compressor unloaded. It has also been found desirable to have about 35 per cent of full-load torque delivered by the armortisseur windings at 95 per cent of synchronous speed that the motor may be in a favorable position to synchronize its load without difficulty. The new motors are guaranteed to deliver 40 per cent of rated full-load torque at starting and also at "pull-in," or 95 per cent speed. These values insure reliability of operation even when used with automatic starters. Torques of 40 per cent will bring the average compressor up to 95 per cent speed in less than 30 sec., after which less than a second is required to reach synchronism.

New Type of Starting Winding

These torques at decreased values of inrush current have been obtained by the development of a new type of amortisseur or starting winding. Where previous starting windings have been made of single or concentric bars placed in slots in the pole tips, the corresponding winding in the new motor consists of not less than three dissimilar bars inserted in each pole slot, together with a single bar of high resistance placed in and opening at each side of the pole. A typical cross-section of these slots is shown in Fig. 3.

The upper bars *C* and *D* are not soldered to the end rings, the principal current-carrying bar *B* being embedded in the bottom of the slots at considerable distance from the pole face. When voltage is first applied to start the motor, full line frequency is induced in the poles and amortisseur windings. At this high induced frequency the current in the principal bars induces a flux in the pole laminations, cutting the idle bars in the upper part of the slot.

The magnetic flux crossing these idle bars increases the reactance in the secondary circuit so as to limit the inrush current. By limiting the current in the principal current-carrying bars, the lateral high-resistance brass bars *A* are enabled to deliver high starting torque; and by the presence of eddy currents within the idle bars the effective resistance of the principal current-carrying bars is increased.

As the speed of the motor increases, the induced frequency in the rotor and the eddy currents decrease in proportion. Thus, at speeds near synchronism, the current-limiting property of the main slot bars has also decreased, permitting a normal flow of current and producing high torque at a speed near synchronism. These starting characteristics are somewhat similar to a wound-rotor induction motor with external resistance, in that the high resistance necessary for high torque is obtained at starting, but the resistance automatically decreases at high speeds, permitting the flow of current necessary for high pull-in torque near synchronous speed.

It has been estimated that, in the average motor winding, the eddy currents in the idle bars at starting increase the resistance of the principal current-carrying bars to approximately 70 per cent more than would obtain if these additional bars were omitted and the slot left empty or made narrow between the main bar and the pole face. By this design the characteristics of the motors may be quite accurately controlled by properly proportioning the two idle bars.

Pull-Out Torque at Rated Voltage

This motor will deliver not less than 140 per cent of rated full-load torque at rated voltage before falling out of synchronism. Motors driving compressors are rarely overloaded, and this value permits the motor to carry safely full rated load, if the line voltage should drop to 75 per cent of its normal value. Greater than 140 per cent pull-out torque unnecessarily penalizes other desirable characteristics mentioned later.

Motors driving ammonia compressors usually operate for long periods without interruption, placing special value on efficient continuous operation as compared with favorable starting characteristics. In order to increase efficiencies to compare favorably with those of the higher-speed belted induction motor, the poles of the new motor have been altered and so assembled as to decrease the average air gap while still maintaining safe clearances (see Figs. 4 and 5). It will be noticed

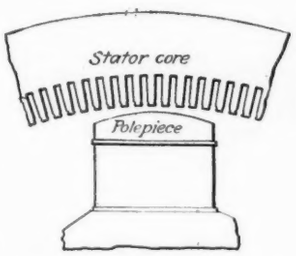


Fig. 4—Pole face of conventional type synchronous motor

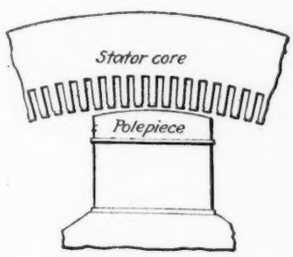


Fig. 5—Pole face of new type of synchronous motor

that the poles of the new motor have a more average air gap, and that the minimum clearance has been slightly reduced. This feature has resulted in a material reduction in the amount of direct-current excitation, permitting the use of smaller exciters. The efficiencies of these motors have been raised and are very nearly constant throughout the range between half and full loads. All efficiencies are guaranteed in strict agreement with the standards of the A.I.E.E.

High-Back-Pressure Turbines as Applied to Existing Stations

By HANS DAHLSTRAND*

STATIONS containing 10,000-kw. units at pressures of 250 to 160 lb. may be improved from about 18 to 30 per cent of present thermal unit efficiency by the application of high-back-pressure turbines for 700 deg. F. steam, exhausting into the present prime movers. A similar gain of 16 to 24 per cent may be possible where 30,000-kw. units are installed. The highest pressure for which commercial boilers are generally available is 550 lb. gage. If steam at this pressure and 700 deg. F. were passed through a high-back-pressure turbine and from thence into present large units of average pressure, it would introduce no conditions that would cause the existing unit to suffer a loss in economy. This is because the resulting throttle temperature and the exhaust-steam moisture content would correspond to the normal ranges for the older high-efficiency stations, which are 475 deg. at 160-lb. gage to 550 deg. at 250-lb. gage. Reheating and stage bleeding are not herein considered.

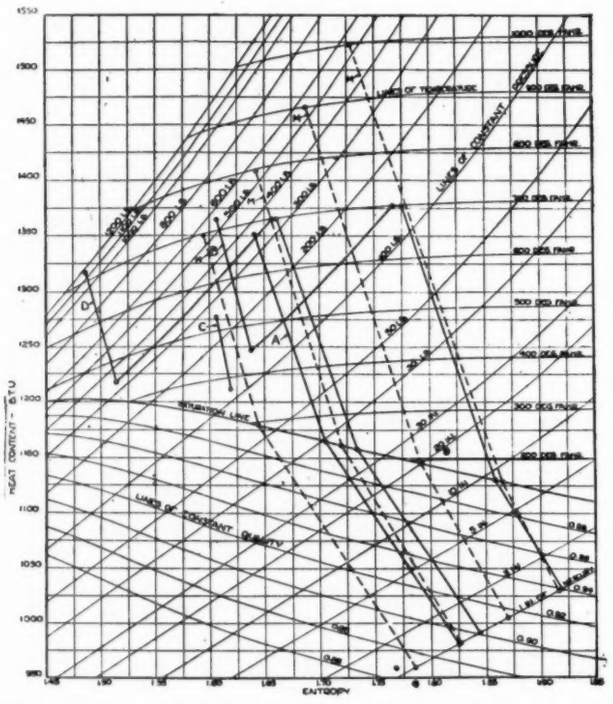


Fig. 1—Expansion curves for turbine units as indicated below, plotted on Mollier diagram

A.—Single-cylinder, 50,000-kw. uni-directional, double-flow reaction turbine, 350 lb. 700 deg. F. steam, 29 in. vacuum.

B.—Two-cylinder, two-generator, cross-compound 50,000-kw. unit, 550 lb. 700 deg. F. steam, 29 in. vacuum with reheating at 120 lb. (general characteristic for impulse or reaction).

C.—High-back-pressure 5,000-kw. 1,800-r.p.m. unit with operating efficiency of 75 to 85 per cent; 250 lb. gage steam, about 100 lb. exhaust.

D.—Proposed 1,200-lb. turbine expanding to 29 in. vacuum with reheating at about 350 lb. abs.

M.—Turbines for 550 lb., 29 in. vacuum and steam temperatures of 700, 800, 900 and 1,000 deg. F., considered with regard to Fig. 2. Conditions at temperatures above 700 represent calculated values only and therefore are tentative.

The expansion curves for the present units such as the general type of cross-compound at the Crawford Avenue Station of the Commonwealth Edison Co., a high-back-pressure turbine ranging from 75 to 85 per cent efficiency in operation, and others, are plotted to a Mollier diagram, Fig. 1.

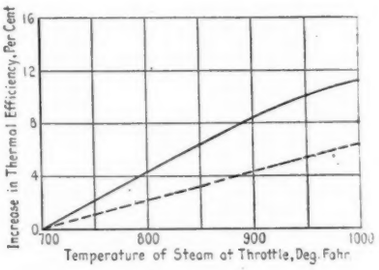


Fig. 2—Thermal efficiency increases shown by dotted line for raising temperatures on 550-lb. turbine; probable actual efficiency increases, full line

In applying a high-back-pressure turbine to an existing station, an important point is whether the steam passed into the existing units will be wetter or less superheated than normal. Fig. 3 analyzes these conditions for various pressures applied to the high-back-pressure turbine at 700 deg. F. up to 1,200-lb. gage. Pressures as low as 550-lb. gage may be applied to give conditions of the older high-efficiency stations such as 475 deg. 160 lb. and 550 deg. 250 lb. at the secondary throttle.

The gain in percentage of thermal efficiency of existing units of 10,000-kw. capacity that would result by applying high-back-pressure turbines is analyzed in Fig. 4. The actual gain will exceed the theoretical except at the region of maximum pressure elevation. The falling of actual gain is marked at 1,000 lb. and above. This results from moisture being formed in the lower pressure stages. Reheating the steam before admission to the existing units is not here considered.

Engineers who desire to investigate the improvement possible by applying the high-back-pressure turbine may find Fig. 5 a convenience where gains over present units with a broader range of efficiencies are given.

The effects of elevating temperatures on the efficiency of a turbine at 550 lb. steam are indicated in Fig. 2. These data are confirmed by tests at 700 deg. and represent probable values up to 1,000 deg. Expansion lines for such turbines are shown at *M*, Fig. 1.

While there is a tendency to concentrate the moisture present in lower-pressure stages near the periphery of the turbine blading, the author's investigation has shown that the cylinder wall is not covered by a continuous film of water. Devices to remove water at the lower stages will probably have slight effect in reducing efficiency.

The result of extensive tests on the effect of temperature on the tensile strength of materials including that of a special alloy developed for elevated temperatures appears in Fig. 6.

*Steam Turbine Engineering Department, Allis-Chalmers Manufacturing Co. Abstract of paper, "A Review of Steam Turbine Development," presented at the May 18-21, 1925, meeting of the A.S.M.E. at Milwaukee, Wis.

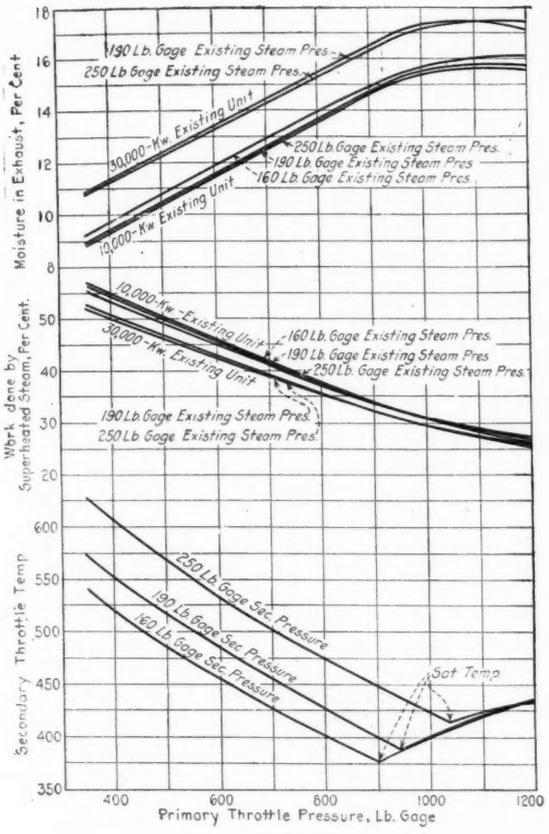

190 Lb. Gage Existing Steam Pres.
250 Lb Gage Existing Steam Pres.
30,000-Kw Existing Unit
10,000-Kw Existing Unit
250 Lb Gage Existing Steam Pres.
190 Lb Gage Existing Steam Pres
160 Lb Gage Existing Steam Pres.
10,000-Kw Existing Unit
30,000-Kw Existing Unit
160 Lb. Gage Existing Steam Pres.
190 Lb. Gage Existing Steam Pres
250 Lb. Gage Existing Steam Pres.
190 Lb Gage Existing Steam Pres.
250 Lb Gage Existing Steam Pres.
250 Lb Gage Sec. Pressure
190 Lb Gage Sec. Pressure
160 Lb Gage Sec. Pressure
Sat Temp.
Moisture in Exhaust, Per Cent
Work done by Superheated Steam, Per Cent.
Secondary Throttle Temp.
Primary Throttle Pressure, Lb. Gage

Fig. 3—Internal steam conditions as result from applying high-pressure turbines to existing plants without reheating

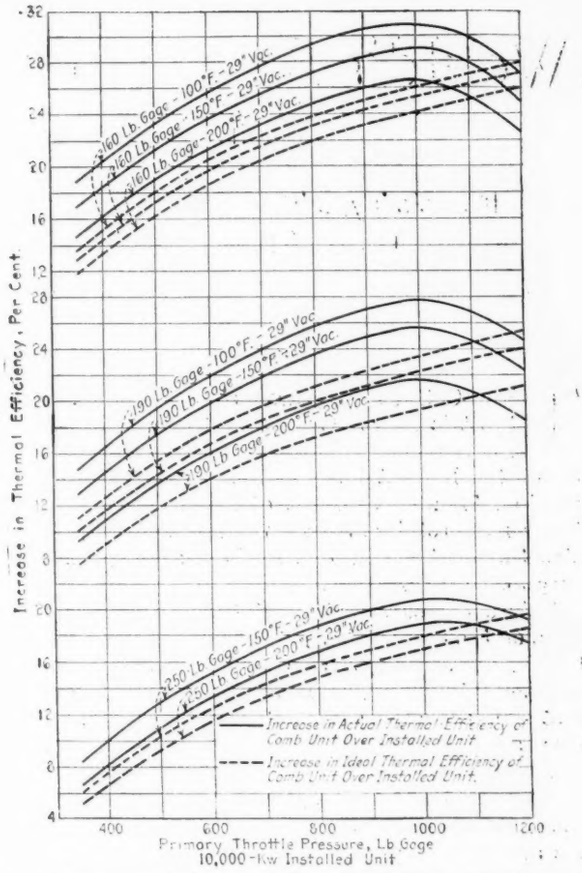

160 Lb. Gage - 100°F. - 29" Vac.
160 Lb. Gage - 150°F. - 29" Vac.
160 Lb. Gage - 200°F. - 29" Vac.
190 Lb. Gage - 100°F. - 29" Vac.
190 Lb. Gage - 150°F. - 29" Vac.
190 Lb. Gage - 200°F. - 29" Vac.
250 Lb. Gage - 150°F. - 29" Vac.
250 Lb. Gage - 200°F. - 29" Vac.
Increase in Actual Thermal Efficiency of Comb. Unit Over Installed Unit
Increase in Ideal Thermal Efficiency of Comb. Unit Over Installed Unit.
Increase in Thermal Efficiency, Per Cent.
Primary Throttle Pressure, Lb Gage
10,000-Kw Installed Unit

Fig. 4—Increase in percentage of present-unit thermal efficiencies by applying high-pressure units without reheating

NOTE—A "high-pressure" unit is assumed to use steam at 700 deg. F. in Figs. 2, 3 and 4. If superimposed on an existing installation, its exhaust is to pass directly into the main units without reheating. No account has been taken of the gain to be obtained by using extracted steam for feed water heating on the older units.

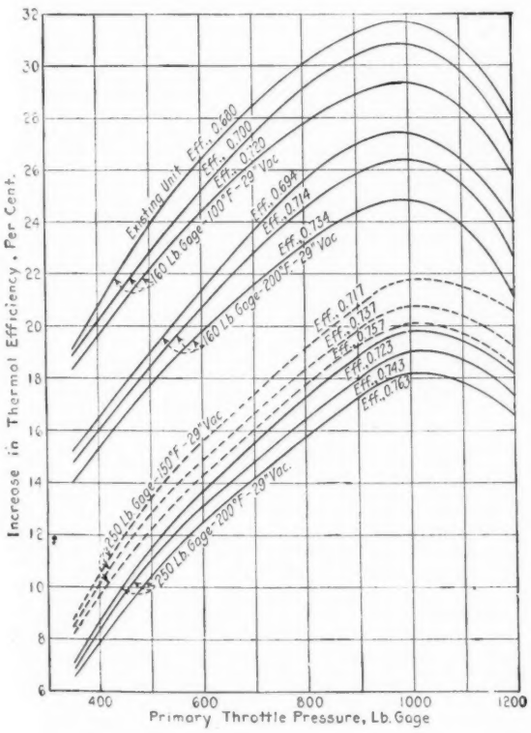


Fig. 5—Shows how different existing efficiencies affect results when high-pressure units are applied

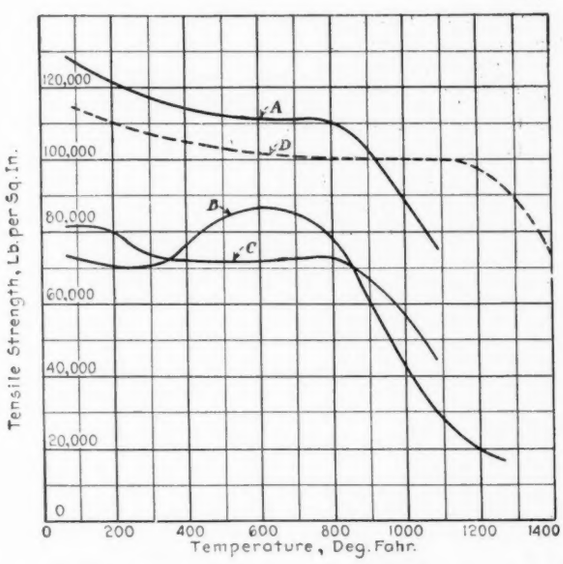


Fig. 6—Tensile strengths of metals at high temperatures

(A) Rolled high-chrome, high-nickel steel. (B) Forged 3½ per cent nickel steel. (C) Forged monel metal. (D) Metal suitable for higher temperatures.

World's Record High-Head Reaction-Type Hydraulic Turbine*

Francis Type Turbine of 35,000-Hp. Capacity Operating Under a Net Effective Head of 850 Ft.—Many Interesting Construction Features in the Pipe Line, Surge Tank and Penstock

By C. P. DUNN
Designing Engineer, Portland Electric Power Company, Portland, Oregon

THE Oak Grove power station of the Portland Electric Power Co. warrants particular attention for a number of reasons: The turbine operates under the highest head in the world for units of the reaction type; the unit is of large capacity and relatively high rotative speed; the length, design and construction of the flow line and the arrangement of the surge tank are interesting.

Before the construction of Oak Grove station there were on the company's system four hydro-electric plants having an aggregate of 60,500 kw. and three steam stations totaling 35,000 kw. The general layout of the system is shown in Fig. 9. The steam plants ordinarily burn sawmill refuse, but are equipped for oil burning when the former class of fuel is not available.

With the comparatively large steam installation and with considerable overdevelopment at the hydro-stations, the system was well equipped for carrying peak loads, and as the trend of growth indicated a constantly increasing load factor, it was desirable that the next generating station should be a hydro-electric plant that could furnish base power at nearly a practicable 100 per cent plant load factor. The Oak Grove site was found to be admirably suited to the needs of the system. The outstanding characteristics are:

1. The stream flow of the Oak Grove Fork of the Clackamas River is remarkably uniform and dependable in dry seasons.

2. The site is better suited for a base-load than an over-developed peak-load plant, because of the high head and long conduit.

Water is taken from the Oak Grove Fork, a tributary to the Clackamas River, 6.6 miles above the plant, and in the present stage of the development of the project the normal flow of the stream is required to operate at full capacity the single unit that has been installed. This stream, having its source in mountain springs, fluctuates in flow between 325 and 600 sec.-ft. at the dam site the 400 sec.-ft. required in the present installation being available nearly the entire year.

A static head of 930 ft. is developed by the construction of about seven miles of conduit. This worked out to be more economical than dividing the site into smaller lower-head developments. The ultimate development is planned to be 1,200 sec.-ft. after the streams in the upper portion of the watershed have been partly controlled by storage. The step recently completed and placed in operation is a 400-sec.-ft. development with one 35,000-hp. unit operating under 850-ft. net head, no storage being necessary until more than 35,000 hp. is required from the development.

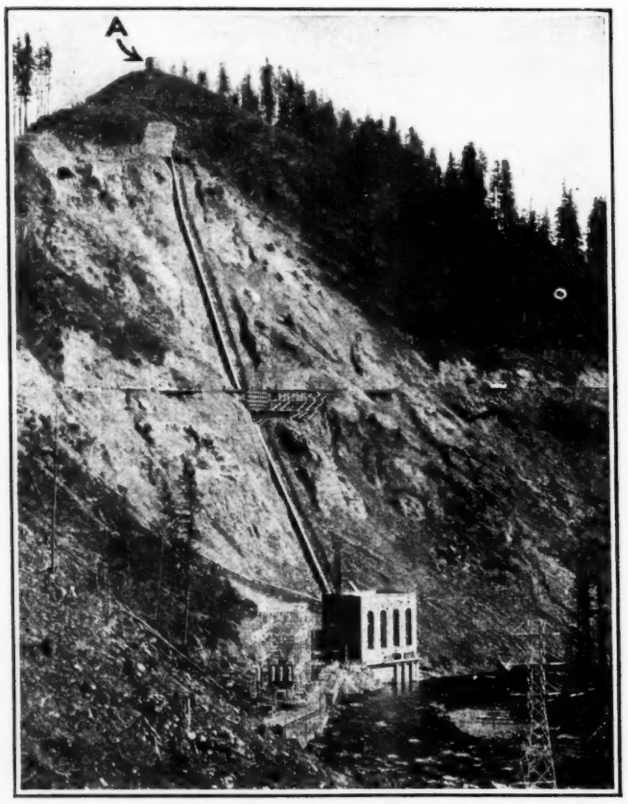


Fig. 1—The top of surge tank at "A" is at an elevation of 937 ft. above the tailwater of the power house

Fig. 8 shows a profile and plan of the development and the general features of the project. The first 1,500 ft. of conduit below the small arch diversion dam is composed of concrete-lined tunnels and concrete pipe. Leading from the tunnel is about 6 miles of steel conduit 9 ft. in diameter, that connects into a tunnel that pierces a knoll just above the power house. In this knoll is constructed the surge tank, the top of which can be seen at *A*, Fig. 1.

The intake dam is very simple, being formed by a concrete arch 68 ft. high and 160 ft. long, with a front shaped to carry a 7,000-cu.ft.-sec. flood. As shown in Fig. 8 the upstream face of the dam has been undercut 7.5 ft. This was done to save in construction material, since without the additional concrete the stresses in the arch are only 10 tons per square foot.

*General design of the entire project, exclusive of the electrical and the detail design of the dam flow line, surge tank and penstocks, was made by the J. G. White Engineering Corp., New York City. Detail design of the power house and the electrical layout were worked out by the engineering staff of the Portland Electric Power Co.

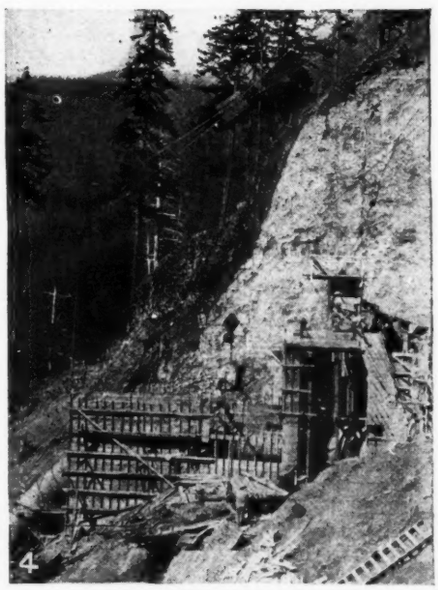
Fig. 2—The summits of the pipe line are equipped with 18-in. air valves and the siphons with 12-in. drains

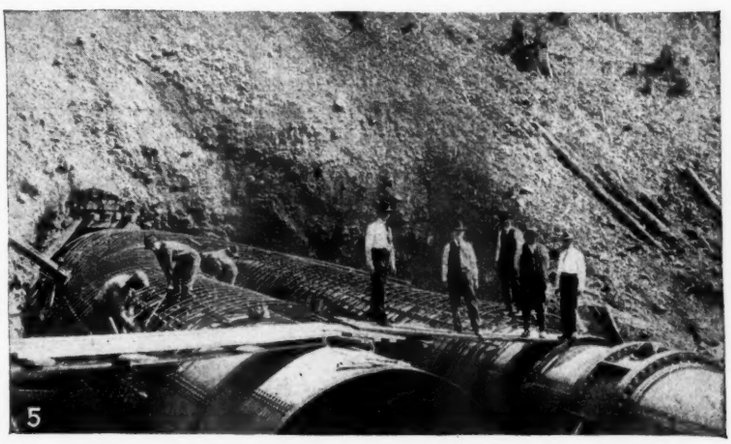
Figs. 3 and 6—There are three steel bridges and one concrete bridge on the pipe line

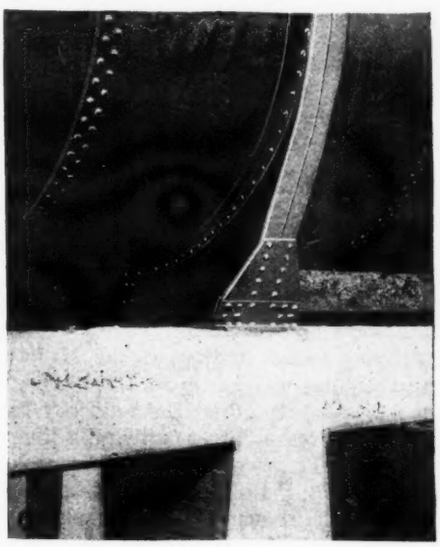
Fig. 4—Concrete anchor at top of penstocks weighing 800 tons

Fig. 5—Reinforced-concrete transition from 12-ft. 4-in. concrete-lined tunnel to 9-ft. and 11-ft. 6-in. steel pipe lines

Fig. 7—For a greater part of the pipe line's length it is laid in a shallow-trench following the irregularities of the terrain







Provisions have been made in the crest of the dam for the installation of 2-ft. flashboards. The pondage afforded with water at the top of the flashboard, with drawdown to within 2 ft. of the gate openings, gives a volume of about 200 acre-ft. which is sufficient to run one generating unit for 6 hours under full load.

Although only one unit has been installed, the intake headworks and the tunnels have been completed for the ultimate development. The intake consists of three branches, the center one of which is the only one that gates have been provided in at present, racks being provided in all three sections.

On account of the difficult topography of the country, for approximately 1,500 ft. immediately below the intake the water is carried in a concrete-lined tunnel, 12 ft. 4 in. in diameter, which has been constructed for the full capacity of the development. This consists of two sections of tunnel with about 200 ft. of reinforced-concrete pipe in between the two. In this pipe a rock trap with a sluice gate is provided to catch any gravel or heavy material that might pass the intake racks and enter the flow line. The trap is a depressed section of the conduit with its bottom sloping toward the sluice gate, which is opened periodically to expel the material that has collected. A large part of the material through which these tunnels were driven was of a nature that required timbering. The portions of the tunnels from which timber could not be removed as concrete was placed, required reinforcing steel sufficient to withstand the full static head, which is a maximum of 60 ft. at the lower end of the second tunnel, 1,500 ft. below the intake. The steel reinforcing was designed for only 6,000 lb. stress per square inch in order to prevent opening up of hair cracks in the concrete.

At the lower end of the second tunnel which is the terminus of the present 1,200-cu.ft.-sec. construction, a 9-ft. diameter steel pipe begins and provision is made for connecting up an 11-ft. 6-in pipe at a later date. The manifold, or "Y" branch, by which the transition is made from a circular tunnel to two pipes, is built of reinforced concrete with a minimum thickness of 18 in. (see Fig. 5). On top of this concrete structure retaining walls were built, and the weight of some 15 ft. of earth fill was added to that of the structure in order to bring the total weight up to 1,500 tons, which is the amount necessary to resist the tendency to move due to temperature stresses after both pipe lines shall have been installed. The two pipe lines are each to be equipped with valves at this point, and also at the entrance to the surge tank some six miles below, so that either line may be down for repairs or painting while the other is in service. Two 9-ft. butterfly valves are

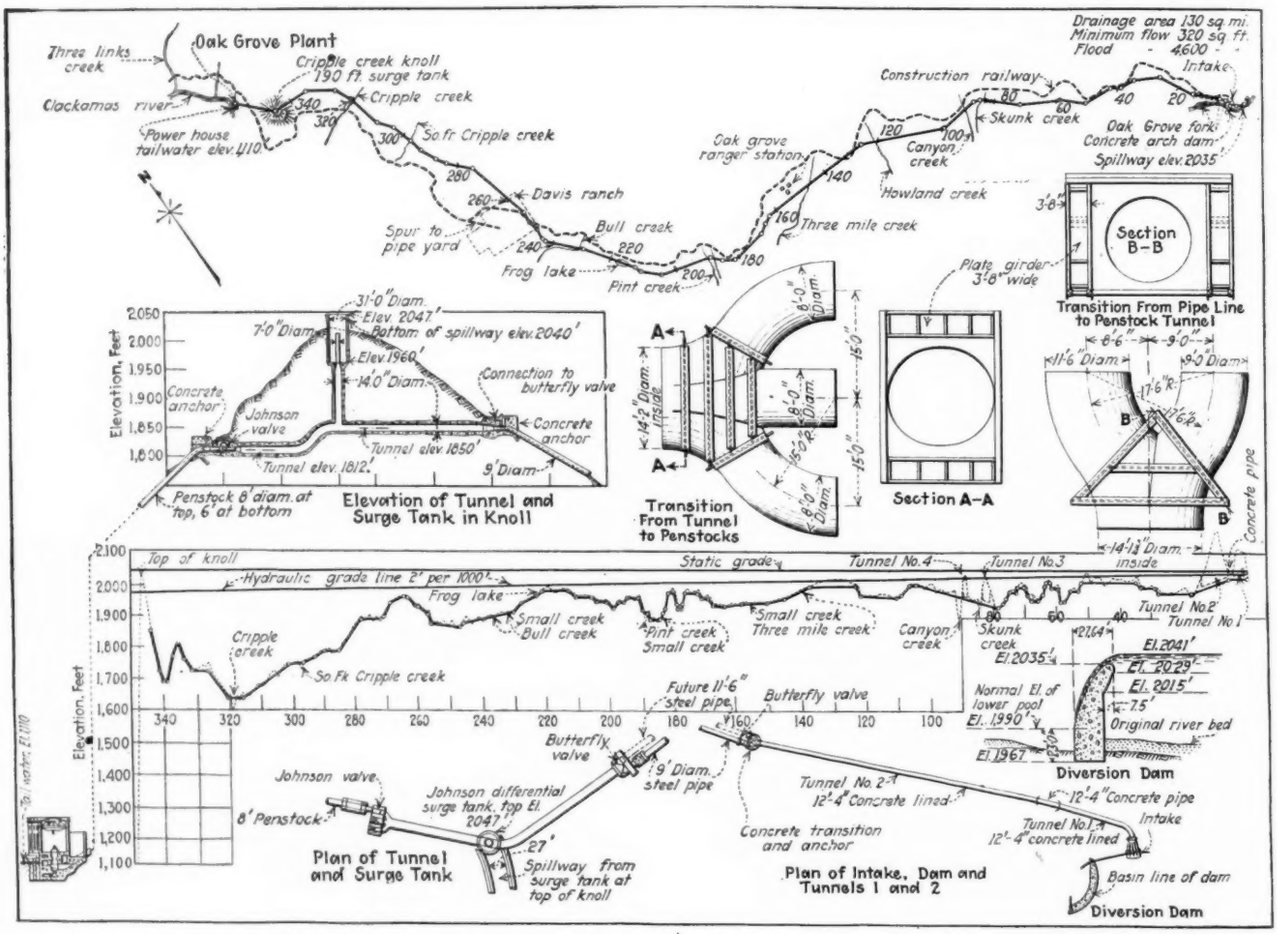


Fig. 8—Plan and profile and general features of the development

Beginning on the right, the first 1,500 ft. of conduit below the small arch diversion dam is composed of concrete-lined tunnel and concrete pipe 12 ft. 4 in. in diameter. Leading from the tunnel is about 6 miles of 9-ft. steel conduit that connects into a tunnel 14 ft. in diameter, which pierces a knoll just above the power house. When the project is completed, two additional penstocks and an 11-ft. 6-in. steel conduit will be installed, which will bring the capacity of the plant up to 105,000 horsepower.

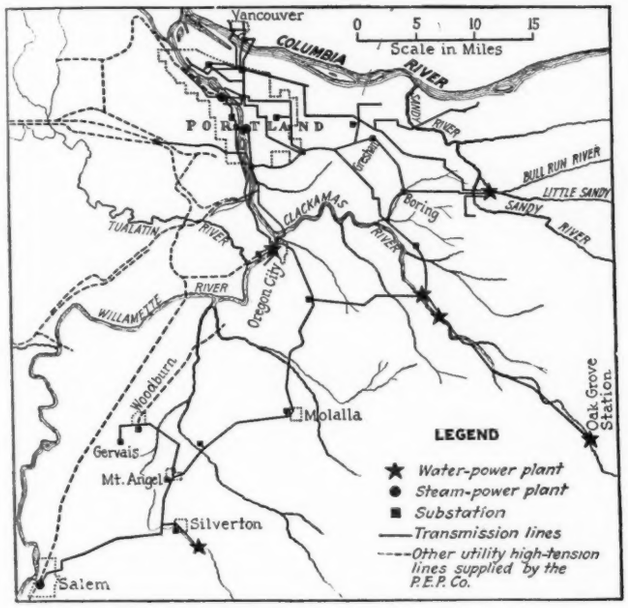


Fig. 9—General map of company's power system

now installed in the present pipe line, one at each end.

For a greater portion of the pipe line's length it is laid in a shallow trench following the irregularities of the terrain, Fig. 7, except at a few points where canyons are bridged and where two hills are tunneled. There are three steel bridges, one of which is shown in Fig. 3, and one concrete bridge on the pipe line. On bridge structures the pipe is carried on steel cradles, Fig. 3, and the pipe acts as a girder between supports. Two short tunnels about two miles below the intake were in material that required timbering. The steel pipe was carried entirely through these tunnels and the space between the pipe and timber filled with lean concrete, placed with air. The conduit has been designed with a hydraulic grade line that falls two feet per thousand. The minimum thickness of plate is $\frac{9}{32}$ in., and longitudinal seams are designed for 15,000 lb. stress in net section of plate.

All pipe made of $\frac{3}{8}$-in. plate and thinner is stiffened at 7-ft. 9-in. intervals with 5x3-in. angles, as indicated at the left in Fig. 7. Plates heavier than $\frac{3}{8}$ in. are not stiffened. All curves, both vertical and horizontal, are 40 ft. radius, it having been estimated that this relation of radius to diameter would give the minimum total friction loss due to curvature. No expansion joints are used anywhere in the pipe. It is expected that temperature stresses with the pipe empty will be almost up to the elastic limit of the net section of metal in the girth seams. During erection the pipe withstood severe temperature changes with no apparent damage. Anchors are infrequent, but are placed near all important structures, bridges, tunnels, valves, etc. The earth backfill extends up to about a foot below the horizontal axis, with a three-foot berm. The summits are equipped with 18-in. air valves, Fig. 2, and the siphons with 12-in. drain valves. The air valves are housed, and provision is made for a one-kilowatt electric heater at each valve in cold weather.

The topography is such that it was convenient to build the Johnson differential surge tank in a conical-shaped knoll through which a tunnel was driven to connect the pipe lines with the penstocks (see Fig. 8). The 9-ft. pipe line terminates at the east face of this knoll, at which point provision is made for connecting in, at at later date, to the lower end of the 11-ft. 6-in. pipe previously mentioned. A plate-steel "Y" branch connects the pipe to the tunnel portal, under a 190-ft. static head. This "Y" is cast into a concrete block reinforced by 3-ft. 6-in. plate-steel girders, as indicated at the left in Fig. 8. The tunnel through the knoll and the riser to the surge tank are made 14 ft. in diameter, sufficient for the ultimate 1,200 sec.-ft. capacity. For the greater part of its 31-ft. diameter the surge tank is in rock excavation, concrete lined, only about 30 ft. of its height being above the ground at the top of the knoll. Above the ground the tank is reinforced concrete. The design is such that the functioning of the tank will be dead beat on an instantaneous change from 600 sec.-ft. to 1,200 sec.-ft. load. A float in the tank is arranged to actuate a water-elevation telegraph on the station switchboard. This instrument indicates, and can be arranged to record continuously, the water elevation in the surge tank.

At the west, or lower, portal of the tunnel through the knoll the tunnel terminates in a triple plate-steel transition which divides the tunnel into three 8-ft. branches for penstocks, two of which are for the present blanked off with dished plate-steel boiler heads. This transition is also anchored into a concrete block reinforced with 3-ft. 6-in. plate-steel girders, as indicated in the center of Fig. 8.

The riveted penstock, 1,200 ft. in length from the

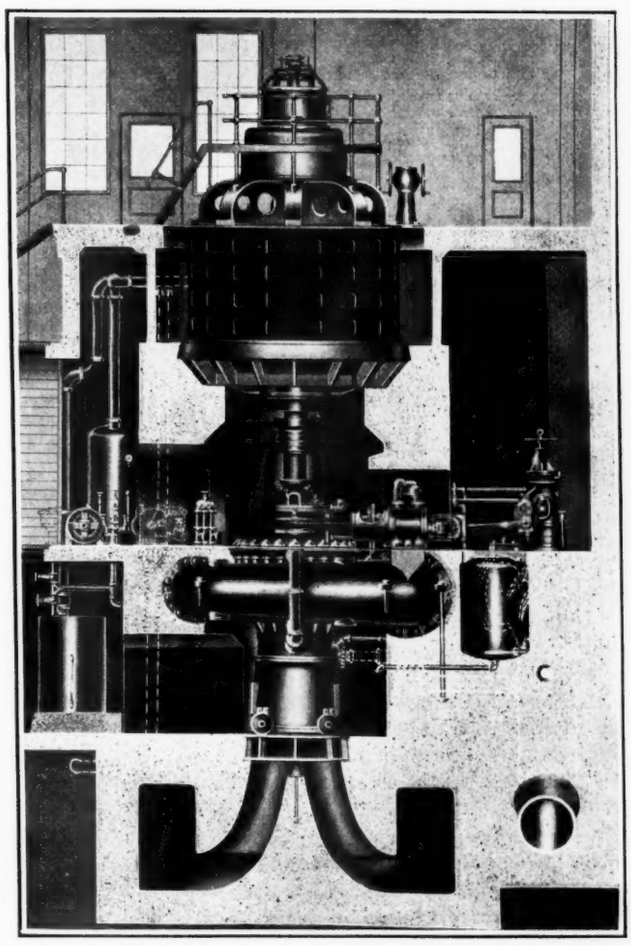


Fig. 10—Turbine rated at 35,000 hp. at 514 r.p.m. and operated under an 850- to 930-ft. head

triple manifold to the power house is 8 ft. in diameter at the top where the static head is 240 ft., and 6 ft. diameter at the bottom, where the static head is 930 ft. All longitudinal seams are triple- and quadruple-riveted double-butt-strap joints, designed for 12,000 lb. stress in net section of plate, based on the static head. This low design stress makes ample allowance for water hammer. The girth seams are double-riveted, single outside butt-strap joints. Changes in diameter from 8 to 6 ft. are made in 6-in. steps at uniform intervals by means of taper sections 8 ft. long. There are no expansion joints in the penstock, and an 800-ton anchor is provided at the top, Fig. 4, and the power-house substructure at the bottom forms an anchor of greater than 800 tons weight. The entire penstock is incased in a concrete envelope 6 in. thick, reinforced with ½-in. round steel 18-in. centers both longitudinally and circumferentially.

At the top of the penstock, immediately below the triple manifold, a 66-in. Johnson valve is installed for emergency protection. This valve can be closed from the switchboard room, the control button being in a glass case similar to a fire-alarm telegraph station. The

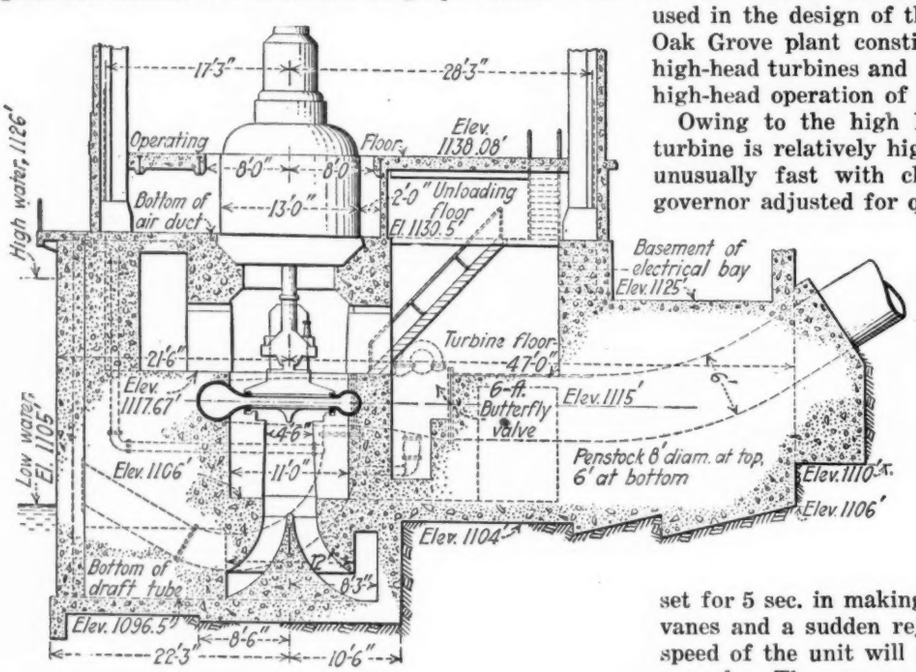


Fig. 11—Penstock connects to turbine casing through a 6-ft. butterfly valve, which is a world's record for high-head operation of this type of valve

valve will also close automatically if the velocity of flow through it becomes twice normal.

At the turbine a 72-in. butterfly valve is installed. This valve is used for all ordinary operating requirements and is controlled both by a motor and by a reversible Pelton impulse waterwheel. It is fitted with an 8-in. needle-valve bypass.

Immediately below the butterfly valve and forming part of the same casting, a "Y" branch is provided for connection to the relief valve, which has a 40-in. diameter discharge with a capacity of 85 per cent of the full flow of the penstock. This relief valve is mechanically connected to the servomotors on the turbine and can be adjusted to open in synchronism with the servomotor closing stroke, the valve then closing slowly, or it can be adjusted to remain continually in opposition to the position of the wicket-gate control mechanism in such a way that the flow in the penstock will remain practically constant, regardless of the load on the unit, that portion of the water not required by the unit flowing through the relief valve.

The butterfly valve is arranged with an 8-in. bypass which may be operated manually at the valve and remotely from the operating floor. This bypass permits filling of the wheel casing and equalizing the pressures on both sides of the butterfly valve before opening. It also provides a more refined control of the water to the wheel than is possible through manipulation of the butterfly valve. By using the bypass valve, a positive means is provided for controlling water to the wheel when starting and synchronizing the unit.

The turbine, which was built by the Pelton Water Wheel Co., is a vertical unit of the Francis type, revolving 514 r.p.m. and developing 35,000 hp. with a discharge of 400 cu.ft.-sec. under a net head of 850 ft. The specific speed is 21.5. Rubber seal rings are used. The casing is cast steel and the runner of navy bronze. The previous record for the world's highest-head turbine installation was held by the Kern River No. 3 plant, Southern California Edison Co. for about three years. This plant embodied for the first time many of the features successfully demonstrated and again used in the design of the Oak Grove installation. The Oak Grove plant constitutes a new world's record for high-head turbines and also a new world's record in the high-head operation of butterfly valves.

Owing to the high head, the normal speed of the turbine is relatively high and the changes in speed are unusually fast with changes of load, even with the governor adjusted for quick action. With the governor set for 5 sec. in making full-stroke closing of the guide vanes and a sudden rejection of 100 per cent load, the speed of the unit will reach 134 per cent normal in 2½ seconds. The runaway speed of the wheel is between 185 and 190 per cent normal. With the relief valve adjusted for full opening stroke and the governor closing in 5 sec., the pressure rise in the penstock is calculated not to exceed 4 per cent on full load rejection.

The draft tube is of the Moody spreading type. Accessibility to the turbine runner and means for quickly renewing wearing parts in the interior of the machine is provided for by making the portion of the draft tube immediately below the turbine casing of cast iron and in two sections. It has been arranged to remove the bottom section first by lowering it a short distance so that the roller-bearing car wheels with which it is provided will engage a track in the substructure. The draft-tube section can then be easily rolled out upon its own wheels (see Figs. 10 and 11). The top section of the draft tube is similarly fitted with four wheels, and it is so arranged that the runner may be directly attached to it and lowered with it to the same tracks used for the removal of the bottom section.

Thermocouple Easily Made for Small Plant Temperature Measurement

By CHARLES E. COLBORN
154 Locust Avenue, Fairmont, West Virginia.

DETERMINATIONS of superheat temperatures in the smaller plants are seldom made regularly because of the difficulties and cost connected with the average temperature-measuring equipment. A comparatively cheap, easily-made and accurate device is herein described.

MANY installations are provided with wells in the steam piping to permit the insertion of thermometers. However, in taking a measurement of superheated steam with a thermometer inserted in a well, there may exist an error caused by the difference in temperature between the immersed part of the thermometer and the emergent portion. This error, usually of such nature as to give a reading lower than the truth, may with rapid temperature variations be high owing to lag. Measurements taken in this manner are of doubtful value in a majority of cases and may even lead to serious errors in data based upon them.

Thermocouples may be used in the same manner, and it is possible thus to obtain much closer measurements of temperatures. With the ordinary thermocouple, however, inserted as shown in Fig. 1 at *A*, there is still liability of error due to variation in temperature of the mercury or solder in the well throughout its depth, and to the amount of submergence of the hot junction of the couple, as well as to the radiation from the protecting tubes around the couple.

In one instance, when using a No. 22 gage base-metal couple insulated with small glass tubing, a temperature curve was obtained, as shown in Fig. 2, by varying the amount that the hot junction was submerged in the well, the latter being of one-quarter inch inside diameter and filled with melted solder. By breaking the glass tubing at the level of the top of the well, as at *A*, Fig. 1, a still further temperature rise was obtained, as noted on the curve Fig. 2. In another case a higher steam temperature was obtained during a boiler test at the point where the superheater leads from a large boiler joined each other than was measured at either of the leads where they left the boiler.

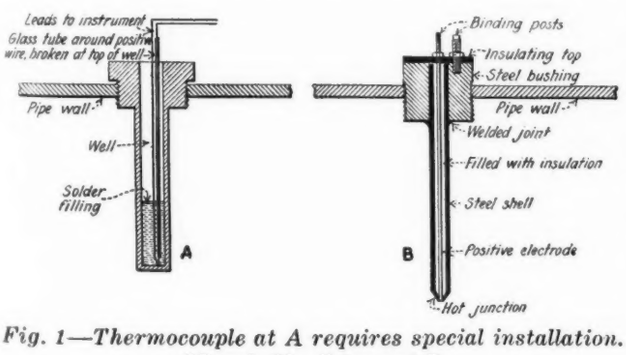


Fig. 1—Thermocouple at A requires special installation. "Spark Plug" type at B

By using couples of this size with the method of installation corresponding to conditions at the right of Fig. 2 carefully followed, and taking temperatures at points on the steam-piping system about 15 ft. apart,

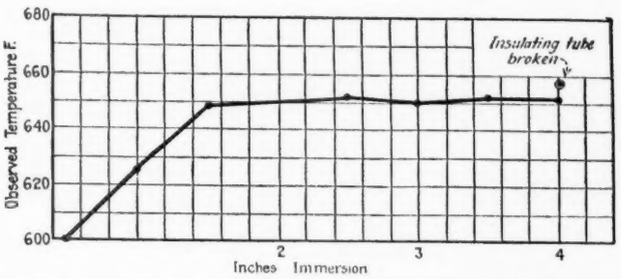


Fig. 2—Temperature variation caused by different degrees of thermocouple immersion

consistent results were obtained. As a consequence, the practice of having the insulation broken at the well mouth was adopted in similar measurements thereafter.

The writer has recently developed a couple, the "Spark Plug" type, which will give good results in service and is sturdy and simple in construction. Fig. 1 at *B* shows a cross-section and the construction. The joint at the pipe may be made steamtight by welding the couple tube to the lower surface of the bushing as shown, and it is best in practice to install these plugs in a saddle welded to the pipe. The inner separation was made by a glass tube in the experimental plugs, although any heat-resistant insulation should be satisfactory. Iron and constantan were the metals used, welded together at the junction, although any other base metal couple should give as good results. Owing to their strong construction, no trouble was experienced from defective couples. The hot junction on these was designed to be placed about midway of the pipe diameter, as it was thought that readings taken at this point would have a more constant relation to each other than at some other point thought to represent the average of the whole pipe.

It is possible to purchase a couple of this general type, which may be well adapted for such use by putting on the necessary bushings, etc. When equipped with the proper leads and galvanometer, it will give accurate results. Such an outfit being comparatively inexpensive, puts within the reach of many small plants a means of obtaining accurate steam-temperature measurements. The materials for the couple can be bought and a couple made and installed for approximately $5. A galvanometer at a cost of around $100, would make it

possible, for about $150, to install quite a complete system of temperature measuring equipment which could be relied on.

When it is considered that the modern turbine changes in efficiency about 1 per cent per 15 deg. F. change in superheat, while the reciprocating engine is still more thus benefited, it can readily be seen that the gain with such an installation to detect and control superheat conditions might easily more than repay the outlay in a short time.

Aluminum as a Protective Coating for Gratebars

In the March 28 issue of the *Zeitschrift des Vereines deutscher Ingenieure*, Robert Hopfeld, Director of the Metalisator A. G. of Hamburg, tells of experiments with gratebars. Bars cast in the ordinary way of gray iron, and chilled bars of the same shape with a mixture of steel, were used simultaneously in a furnace in which, owing to the character of the coal, the bars previously used had burned out rapidly.

After 600 hours of use in the furnace the chilled iron bars, as shown in Fig. 1, had burned away to such an extent as hardly to be of further use.

The bars of ordinary gray iron were also badly burned, although for some unapparent reason the wastage in their case was not so uniformly distributed over the length of the bar.

Although positive conclusions should not be drawn from a single test in which some accidental condition may have had an important influence, the evidence, as far as it goes, indicates that the ordinary gray-iron bar is not more vulnerable than that with the chilled surfaces.

Considering the cause and manner of this rapid deterioration, the author says that at high temperatures iron, especially wrought iron, is rapidly oxidized in contact with air. As soon as the layer of oxide thus formed reaches a sufficient thickness, it peels off and the oxidation continues upon the newly exposed surface. Cast iron is not so sensitive to this action as wrought iron, although cast iron oxidizes rapidly at temperatures in excess of 750 deg. C. (1,382 F.).

All coals contain more or less silica, which, combining with the iron oxide, forms a slag that has a lower melting point than the iron itself. This slag fastens itself upon the bar, and in consequence of its low melting point acts as a flux for the as yet unattacked metal. When the spaces between the bars become obstructed with this slag, the temperature is increased locally by the consequent diminution of the air flow. The falling of fine coal through the grate, and its combustion in the ashpit, further aggravates the condition by heating the incoming air and subjecting the bars to the heat of a fire below as well as above them.

Phosphorus lowers the melting point of the iron. Sulphur in the unused bar appears as small iron-sulphide crystals having a melting point of 1,210 deg. C. (2,210 F.), and in this form does not materially hasten the fusing of the metal. These crystals, however, in an amount of 0.2 per cent, make the iron brittle and encourage flaking and the production of cracks and fissures. For this reason it is desirable that iron that is to sustain high temperatures should have a low sulphur content. Analysis showed, however, that the sulphur content had increased from 0.09 per cent in the unused to 0.95 per cent in the burnt bars.

From the foregoing it appeared that the life of the bars would be lengthened if the formation of iron oxide and the increase of the sulphur content could be prevented. This has been attempted by giving to the bars a coating of aluminum which hinders, through the formation of aluminum oxide, the oxidation of the iron and the absorption of sulphur.

In applying the process, which consists of spraying the aluminum on in a molten condition, the iron should be at a red heat, as the coating applied to a cold surface is likely to include air, which, by its expansion when the bar is heated, is likely to impair the integrity of the protective surface and make the aluminum flake off.

Fig. 1—Chilled bars after 600 hours' service

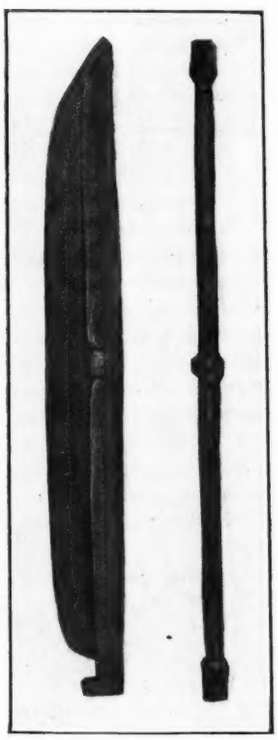


Fig. 2—Metalized bars after 600-hour test

Some of the gray-iron bars were thus treated, about 45 grams of aluminum being applied per meter length of bar, and these, simultaneously with samples of the untreated bars, were subjected to a 600-hour test in the same furnace. Their appearance at the end of the test is shown in Fig. 2. Analyses of the sections after this exposure show comparatively immaterial changes in the composition of the section, especially as regards the sulphur content.

There seems nothing easier than to wipe oil from a cast-iron surface with a piece of waste. The inexperienced will ordinarily leave a large spot visible even after careful wiping, while an experienced man who knows the trick may remove all signs of oil in one operation. As a matter of fact, clean waste is a difficult medium for removing all signs of oil, but if it be moistened first, an improved cleaning action will at once become apparent.

Seal Beach

CALIFORNIA, which is second only to New York State—and that because of Niagara Falls—in hydraulic power developments, has of late shown increased activity in the construction of steam-electric stations.

The meaning of this is clear enough. California is gradually catching up with her water-power resources. Yet the demand for power increases and must continue to increase even more rapidly than the population.

Until the time arrives when the large-scale importation of coal will pay, practically all this additional power must come from the chief native fuels, oil and natural gas. This means that Californians must transfer to boilers, steam turbines and Diesel engines some of the attention they have been devoting to dams, penstocks and hydraulic turbines.

A short while ago the Long Beach steam-electric station, rushed through in record time, because of a water shortage, went into operation. Now attention is centered on the Seal Beach station of the Los Angeles Gas & Electric Corporation, the subject of this issue's leading article.

From an engineering point of view the outstanding fact about Seal Beach is the low construction cost—$85 per kilowatt. Yet this station, equipped as it is with air preheaters and four stages of bleeder heating, is expected to place a kilowatt on the line for an hourly heat consumption of 15,000 B.t.u. This combination of high thermal efficiency with extraordinarily low fixed charges spells high commercial efficiency.

Two reasons for the low construction cost are evident from the plan and elevation of the station. One is the compact arrangement of boilers and turbines which keeps down the ground space occupied. Another is the reduced height of the boiler room made possible by the location of air heaters and breeching on the roof. The net result is a low figure for station volume with a considerable reduction in the cost of the building.

These and other engineering features brought out in the article should be of real interest to all who are concerned with the production of electricity at minimum cost.

Fuel Economy in the Electrification of Railways

WITHIN the last twenty-five years remarkable progress has been made in the design of power-plant equipment; the steam turbine, improved methods of firing boilers, the use of higher pressures and temperatures and improved heat cycles, have resulted in a gradual lowering of the heat units per unit of power until at present one kilowatt-hour on one pound of good coal seems to have good possibilities of commercial attainment in the near future.

One of the most marked effects of these improvements is that, although the use of power and heat for industrial purposes is increasing rapidly, coal consumption is practically constant. Last year the bituminous-coal production was about equal to the average for the last seven years. Better utilization of coal is not alone responsible for this condition. Development of water power; burning lower grades of fuel, such as anthracite culm and coke braize; more efficient use of waste heat from industrial processes; greater use of fuel oil under boilers and in oil engines, both in marine and stationary work—all have contributed their part.

In stationary steam power-plant work there still remain great opportunities for improvement, especially in many of the medium and small-sized plants. Another tremendously large field for saving in fuel is the electrification of trunk-line railways, which is again beginning to attract nation-wide attention. It has been estimated that one pound of coal converted into electrical energy in a modern central station and used in an electric locomotive will do the work of three pounds burned in a steam locomotive. This saving, if only one-half of the railway mileage of this country was electrified, would amount to approximately forty million tons of fuel a year. As Gerard Swope, when speaking before a recent meeting of the A.I.E.E. pointed out, "This would be a fine contribution to the conservation of our natural resources, would free human labor in the mines and free investment in handling this tonnage, and increase by more than 10 per cent the carrying power of the railroads so electrified, because this part of the present equipment is now used to transport the coal the railroads themselves consume."

The work of electrifying trunk-line railways has long since passed the experimental stage, and data obtained from hundreds of miles of electrified lines in this country and abroad have more than substantiated the economies claimed for the change from steam to electricity. The possibilities of fuel saving alone by electrification make this field worth the attention of the country's ablest engineers and industrial leaders.

Station for Nine-Hundred-Degree Steam Being Constructed

WHILE temperatures of eight hundred to one thousand degrees Fahrenheit are being used for gases at pressures corresponding to maximum operating steam pressures, yet steam-plant temperatures have not been materially advanced since a six-hundred-and-ninety degree plant began operation eight years ago. In fact, the temperature of the first commercial turbine unit, about four hundred degrees, has been improved only around thirty-eight per cent in twenty-three years, when considered on the basis of absolute temperature, which after all is apparently the fairest criterion. Meanwhile pressures have been increased three hundred per cent with double this amount in immediate prospect.

Although practical and theoretical factors have in the past made pressure advances relatively more advantageous, they also indicate that for the Rankine cycle future pressure increases should be accompanied by higher steam temperatures. Reheating the steam after partial expansion is a well-known alternative to higher initial temperatures or may be used in combination, depending on conditions for which the plant is designed.

While steam temperatures of eight hundred to one thousand degrees are being discussed in this country and England, a contract has been executed in Czechoslovakia for a steam plant utilizing temperatures of 831 to 942 degrees F. at 1,400 to 1,700 lb. throttle pressure, for an 18,000-kilowatt turbine. The plant is to be in operation about August, 1926.

One reason for such temperature apparently is that no reheating will be included. Moisture in the exhaust region will therefore be reduced to a large extent by means of the higher initial temperature. The steam turbine will have four cylinders on a single shaft operating at 3,000 revolutions per minute. Each wheel casing consequently will be subjected to a comparatively small temperature difference between inlet and exhaust. Arrangements for obtaining uniform turbine expansion and other features of such machines include absolute steam velocities of about seven hundred to nine hundred feet per second for the high-pressure end and rigid-type rotors containing single-row impulse stages. The boilers will be rated at about two thousand pounds pressure. A high-back-pressure 2,400-kilowatt turbine of this type tested by Dr. Stodola after one year's operation, showed eighty-two per cent coupling efficiency. Since the contract has been executed and work begun, a comparatively large step in temperature elevation may soon become a commercial reality.

Central-Station Operating Personnel

THE results of an investigation of practices and standards in the matter of central-station personnel have just been published by the Prime Movers Committee of the National Electric Light Association in a serial report entitled, "Central-Station Operating Personnel." While a perusal of this report is enlightening, those who are looking for some general agreement as to the qualifications and training of engineers, boiler-room operators, firemen, etc., will be disappointed.

A questionnaire in the form of a job-specification card for power-plant employees (covering fourteen important positions) was sent to each member of the Prime Movers committee. The items listed were: Name of job, general duties, training and experience, training in plant, educational requirements, personal characteristics, method of pay, hours of work, promotional possibilities and remarks. Replies were received from fourteen companies, representing the largest central stations in the country.

For "chief plant operator" the educational requirements varied all the way from "eighth grade plus much practical experience" to "technical graduate preferred but not essential." There was little agreement as to the personal characteristics required or the possibilities of promotion. In the case of the "plant operator" the educational requirements were so diverse as to indicate that more thought should be given to the matter. According to the report the rate of pay in some cases was altogether too low for the responsibility involved.

In the case of the "boiler-room chief operator" there was more uniformity of opinion. The value of technical training for this job was generally recognized. The jobs of "generating-room chief operator" and "electrical operator" seem to be fairly well standardized. For "coal and ash foreman" the requirements, in the way of personal characteristics, were fairly stiff, with special emphasis on dependability, executive ability, thoroughness and leadership. Yet few of the plants reported any special provision for promotion, which is hard to understand in view of the qualifications required.

The greatest uniformity occurred under the heading of "fireman," the most generally agreed upon personal characteristics desired being intelligence, dependability, physical strength and alertness. As might be expected, little education was required.

Among the other jobs listed, two of particular interest are "test engineer" and "plant statistician." In some plants the test engineer is an important executive whose work requires considerable technical training, while in others he is apparently little more than a low-paid clerk. The same applies in the case of the plant statistician. Here his position is in general that of a clerk, but in one company his greater importance is shown by the fact that he may be promoted to boiler-room engineer.

The great diversity of the replies throughout the report shows that altogether too little thought has been given to this question of operating personnel, whose faithful and intelligent service has an important bearing on earnings and good will.

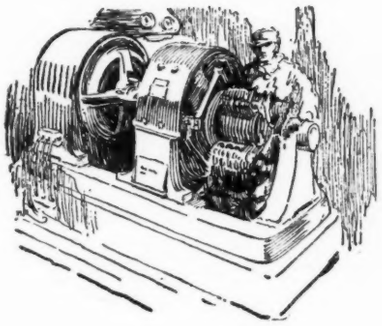
Measuring Water to Hydro-Electric Plants

IN STEAM plants the importance of meters to give an intelligent record of input and output are now generally recognized. The same importance, however, is not so generally placed on meters in water-power plants, although there are examples to show that it is economically sound to provide means of knowing the quantity of water going to the turbine. In one case where venturi meters were installed on the penstocks leading to a plant, an increase of about thirty thousand kilowatt-hours per day was obtained with the same volume of water going through the turbines as used before the meters were installed.

A large percentage of this increase was due to the operator's paying closer attention to maintaining the head at the plant as high as possible without wasting water over the dam. In the hydro-electric plant, as in the steam station, the operator cannot be expected to take the same interest in his work if the results he is obtaining are left to his imagination and there is no means of procuring definite figures on his efforts. Although the problem of measuring water is not in all cases as simple as that mentioned, this instance does indicate the necessity of having a record of input to hydraulic turbines as well as knowing the output of the electric generator.

The old Refractories Association has recently been reorganized into a new Refractories Institute, in which consumers are admitted as associate members. This is a good sign, wherein mutual helpfulness is likely to result in an improved product.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for May will be announced next month.

Changes Made To Improve Operation of Air Compressors

In a plant of which I once took charge there were a number of air compressors supplying low-pressure air at 15 lb. gage and high-pressure air at 100 lb. gage. For supplying the high-pressure air there were one 760-cu.ft. two-stage and one 280-cu.ft. single-stage steam-driven machines, the engine of each compressor being equipped with Meyer cutoff valves. There was also one 400-cu.ft. single-stage machine running at 55 r.p.m. the engine of which had an automatic governor and valve of the grid type. The discharge of the 280-cu.ft. machine was piped so that it could discharge into either the high-pressure system or into the low as the demand for air necessitated.

For supplying the low-pressure air there was a single-cylinder steam-driven machine of 2,350 cu.ft. displacement running at 55 r.p.m., the engine having automatic cutoff valves of the grid type, the same as the 400-cu.ft. machine, also a twin motor-driven compressor of 1,900 cu.ft. displacement. The 2,350- and 400-cu.ft. machines were on the same shaft and were driven by twin engines, the cranks being 90 deg. apart.

The uses of high-pressure air had increased to such an extent that the 760-cu.ft. machine was sometimes unable to supply the required amount of air and as it needed repairs badly on account of being in a dusty location, we installed an intercooler and piped the suction of the 400-ft. machine so that it could take air from either the low-pressure supply through the intercooler, or from the atmosphere. This gave us about 800 cu.ft. of free air from the 400-ft. machine. Later, we piped the suction of the 280-cu.ft. machine in the same way, but left the discharge as it was. This gave us about 280 cu.ft. of air for either the high-pressure system or the low when drawing from the atmosphere, and about 560 cu.ft. for the high-pressure system when drawing through the intercooler.

During the winter our practice was to increase the speed of the 2,350-cu.ft. machine to over 60 r.p.m. in order to get more exhaust steam for the heating system, making up the shortage of low-pressure air, if any, with the motor-driven machine. In the summer we would run the motor-driven machine full load on purchased power and make up the deficiency with the 2,350-cu.ft. machine. As this would run around 1,200 to 1,400 cu.ft. of air, we had to run the machine at a reduced speed. It meant also that we had to run the 400-cu.ft. machine whether we needed it or not.

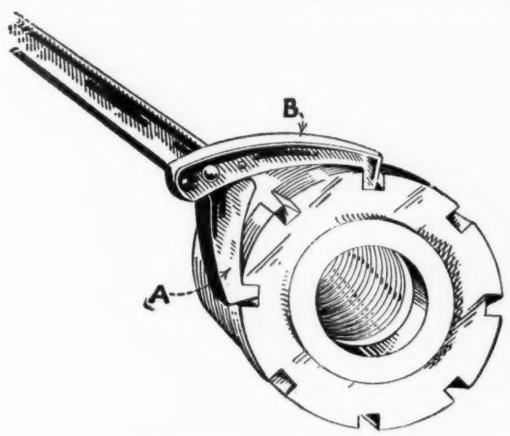
With the new arrangement we were independent of the 760-cu.ft. machine and could get it repaired. We saved steam by running the engines with automatic cutoff and saved oil also, which was not a small item.

Toronto, Ont., Canada. R. MCLAREN.

An Adjustable Packing Nut Spanner for Close Space

A packing nut spanner that will grip the nut better than the regular one-piece wrench and one that may be operated in closer quarters may be made by using two arms pivoted together. This makes a wrench that will fit any size of nut.

The extension of the handle part *A* should be about one-third the length of the pivoted arm *B*. The latter should have several holes through which the fulcrum pin may be placed so as to be adaptable for nuts having



Wrench is adaptable to several sizes of nuts

the notches at various spacings. By making the tool of steel and shaping the lugs carefully, a wrench of this type will not slip and may be folded to occupy less room in the mechanic's kit. G. G. MCVICKER.

North Bend, Neb.

Steam-Chest Gasket Reinforced With Wire Screening

Some time ago, while I was on the morning shift in the power plant, the packing on the steam-chest cover of the air compressor blew out. As it was necessary to get the compressor back in service with the

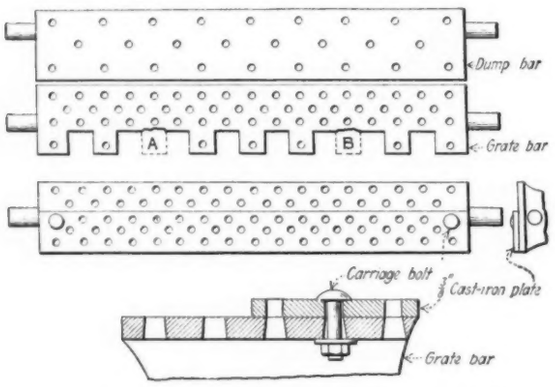
least possible delay, it was shut down and the cover removed at once. I then discovered that there was not a piece of packing in stock large enough to make the gasket required.

As there was no time to lose, I took several small pieces and made a complete gasket from them, making a lap at the ends of each piece. I then got some window screening and cut two pieces the same size as the gasket. In making the joint the rubber gasket was placed between the two rings of screening which served to hold it at the laps. This same packing was holding a year after, when I left, and appeared to be as good as when first put in. HENRY J. TRENK.

Ekalaka, Mont.

Hand Stoker Repair

One of the boilers in our plant is equipped with a hand stoker. A short time ago the fireman found he was unable to move one side of the stoker owing to some obstruction lodging between some of the grate



Grate bars repaired with perforated plate

bars. In trying to get the grate loose he used sufficient force to break one of the bars at the points *A* and *B*. This permitted coal to drop into the ashpit and allowed an excessive amount of air to pass into the furnace.

As there was not another grate bar of this type in stock and it would take from two to three weeks to obtain one from the manufacturers, it was necessary to make a temporary repair as the boiler had to be kept in operation.

When the furnace had cooled off sufficiently, we examined the bar and decided to repair it as shown in the lower view in the illustration. We obtained a piece of flat cast iron $\frac{3}{8}$ in. thick from the scrap pile and cut it to the length of the grate bar and 4 in. wide. Then we drilled a number of $\frac{3}{4}$-in. holes in it and bolted it over the grate bar with two $\frac{1}{2}$-in. bolts placed through the air holes. The plate did not interfere with removing the ashes from the grate, as the broken bar was next to the dump bar of the stoker in the rear of the furnace. The repair was made without removing the grate bar from its place. H. A. JAHNKE.

Milwaukee, Wis.

Firing Oil by Gage

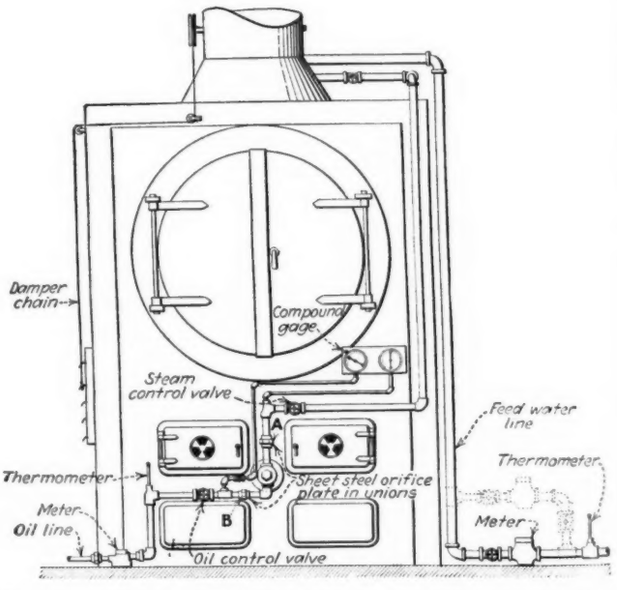
There is no argument needed to convince the fireman in the average plant of the value of getting the most miles per gallon out of the gas he puts in his "Flivver." He just seems to know naturally that it pays. He also knows that it pays in a larger way to get the most heat possible out of the oil used in his furnace, and while the saving goes into his employer's pocket instead of his own, I believe he is just as anxious to make the saving. The reason he fails to do so is because he does not know how to accomplish it without the expenditure of a large sum of money for instruments and other equipment, and not being able to sell his employer on the proposition, he gets nothing and does nothing.

There are average plants, but I do not believe there is any such person as an average fireman. Therefore, I refer to the fireman in the average plant and not to the average fireman.

In the average plant seldom is the evaporation per pound of oil more than approximately known. I believe for the average plant, an evaporation of 12 lb. of water per pound of oil is a reasonable standard and one that can be attained at a comparatively small cost for instruments or auxiliary apparatus.

In the plant of which I have charge, we have exceeded this standard, and the method by which it has been accomplished is quite simple. The only equipment necessary is a hot-water meter, a hot-oil meter, two common feedwater thermometers that read from 40 to 240 deg. F., a 6-in. compound gage reading from 15 lb. pressure to 30 in. vacuum, a 6-in. pressure gage reading as high as the pressure usually carried and a small flue-gas analyzer. The whole outfit can be bought for less than a hundred dollars, and it is quite likely most plants have some of this equipment on hand. I do not advise using anything smaller than 6-in. gages, as the graduations are too close.

The flue-gas analyzer need have only one pipette for the analysis of CO_2. Do not worry about the O or CO.



Gages connected to oil and steam line to burner between control valves and orifice plates show pressures for best operating conditions

This, I realize is contrary to the practice of combustion engineers, but I believe I can prove before I finish that sometimes there is more than one way to accomplish the same thing; and in this instance the "other way" is the more simple and sure.

If operating only one boiler, cut the feed line and put in the hot-water meter and a tee or cross for the

thermometer. If put on a bypass, a small meter will probably do; one just large enough to pass enough water for running conditions, and when filling the boiler or at other times it can be cut out. If operating more than one boiler, put the meter on a bypass so it can be moved from one boiler to another.

Put the oil meter and the other thermometer in the oil line to the burner, and if operating more than one boiler put this meter also on a bypass on each oil-to-burner line so it can be moved easily. Fasten the two gages on a board and put a piece of asbestos millboard behind it and fasten it to the boiler front.

Now cut the ½-in. oil line between the control valve and the burner and put in a union and a ½x¼-in. tee between the control valve and the union. Connect the tee up to the compound gage, being sure to put a ¼-in. gate valve in the connection. This valve must be closed when the burner is blown out or boiler pressure will be thrown on this gage and the gage will be ruined.

Take a small piece of galvanized iron about No. 30 gage, and cut out a blank gasket for the ½-in. union as at *B* in the illustration and drill a small hole in the center. For each of our 1,500-sq.ft. boilers, we use a $\frac{5}{32}$-in. hole with 60 lb. pressure at the oil pump.

In a similar way cut the steam line, putting in a tee and a union connecting the tee to the pressure gage. No valve is needed in this line. Make a ¼-in. hole in the sheet-metal gasket which was put in this union. This is about right we find for a 1,500-sq.ft. boiler, carrying 100-lb. pressure. The idea is to have the holes only large enough to pass the oil and steam necessary for the largest fire required. If the boiler is larger or smaller, vary the size of the hole in the sheet-metal disks accordingly.

It is readily apparent with this arrangement, that when the burner is in operation, both gages will indicate pressure, and it is further evident that any change of the control valves will cause a change in pressure.

The reason for using a compound gage for the oil is, not that there will ever be any vacuum on the oil line, but when only 60-lb. pressure is carried at the oil pump, the burner pressure will probably not be more than 6 or 7 lb. for the largest fire and probably only ½ or ¾ lb. on the smallest fire. A compound gage will register these low pressures better than an ordinary pressure gage.

The entire boiler setting should now be gone over with some good cement and all air leaks stopped. Plaster the whole setting if necessary, but make it airtight. This will pay big returns on the investment.

When putting the boiler into operation, first get out the analyzer, then set the fire to carry the smallest load, open the damper wide, take a sample of flue gas and analyze it. If it reads less than 13 per cent CO_2, pull down the damper a little at a time until a sample is obtained that reads 13 per cent. Then cut down on the steam until the point is found where the least steam can be used and still obtain 13 per cent CO_2. Read the oil and steam gages, making a record of the pressures on a card. Locate a new hook for the damper chain and mark the link No. 1, the same as the fire number. Open the damper slightly by putting the next link of the damper chain on the hook. This will cause the CO_2 to fall, but turn on the oil slightly and the CO_2 will come back up to 13 per cent. Just how much it will be necessary to turn up on the oil and steam will be determined by the analyzer. Work the analyzer and the oil and steam valve until 13 per cent CO_2 is obtained with the least steam. Make a record of these gage pressures, numbering the link of the damper chain to correspond to the fire number as before. Repeat this operation, opening the damper link by link until the largest fire required is reached.

It may take a day or two to finish this job, but keep at it till it is done; then as there is time, check each "fire." You will have a table similar to the following:

Fire No.	Oil Pressure	Steam Pressure	Link No.
1	¾	35	1
2	1¾	45	2
3	3	55	3
4	4¾	62	4
5	6	70	5

Should the oil or steam line become clogged or the oil pump pressure drop for any cause, the fact would be indicated at once by the gages. The sensitiveness of the gages is surprising, and firing this way is extremely fascinating. It saves 50 per cent of the firing labor over the old "cut and try" method as each setting is a positive operation.

With this table of oil and steam pressures and the marked damper chain it is easy to set the fire to carry any load and know that the furnace is operating at its highest efficiency.

Firing now becomes a bit of mechanical routing. It is done by gage and not by guess. You will be greatly pleased when you see how the gages respond to the slightest movement of the valves. The only reason for looking in the furnace now, is to see whether the burner is clogged with scale. If you want to take some of the conceit out of yourself, cover up the gages and adjust the fire the old way by looking into the furnace and guessing. You will miss the setting badly more times than you will come close. Another good thing about firing by gage is that the slightest change of conditions will be indicated on the gage and can be seen from across the boiler room, and the situation can be remedied at once.

To find how good the furnace is as a heat generator and the boiler as a heat absorber, read the oil meter and note the temperature, and change the quantity into pounds of oil at 60 deg. Read the water meter, change it into pounds of water, and multiply it by the factor of evaporation that corresponds to its average temperature. Divide the pounds of water by the pounds of oil, and the answer is the evaporation per pound of oil.

If the meters and thermometers are not obtainable, it will be impossible to arrive at the evaporation per pound of oil. However, if the furnace is operated as outlined in the foregoing, you will know that the maximum is being obtained from every pound of oil, and this will show up in the fuel bills.

What about the O and CO analyzing? That is a simple matter. Run a test on any fire, for example a No. 3 or No. 5 fire, on 12, 13, 14 and 15 per cent CO_2 and adopt for your standard the percentage of CO_2 that gives the greatest evaporation per pound of oil, having in mind that if the furnace will not stand a 13 or 14 per cent fire, it may be necessary to drop the standard to 11 or 12 per cent, even though it is not as efficient.

If you have a good tight furnace, the volume of which is about 0.2 cu.ft. per sq.ft. of boiler-heating surface and a reasonably good burner, 12 lb. of water should be obtained per pound of oil.

A. E. DAVIE.

Los Angeles, Calif.

Comments from Readers

Problems of the Operating Engineer

I was much interested in the article, "Problems of the Operating Engineer," in the April 7 issue, as I find myself in about the same position. I am about fifty years old, and when I approach a prospect I am generally told they want younger men. I have served as chief engineer about ten years and as turbine erecting engineer about ten years. I have operated power plants equipped with oil engines, steam engines, turbines and stokers, also plants fired with hogged fuel and have always tried to leave a plant better than I found it. I have endeavored to do my duty as I saw it. I am considered a good power-plant man and have had extensive experience on locating and correcting turbine troubles. I have had experience in the South and in Mexico, and I am willing to go anywhere that a white man can live.

Until about a year ago I have never been out of a job. I have since tried employment agencies, to no avail. The question is, What am I going to do? as I have a family to support. I am a member of engineering and fraternal organizations.

A position as chief engineer, assistant or maintenance engineer or master mechanic would suit me all right. I am able to furnish good references, as I have received salaries up to $400 per month. I believe there is a place for every man but the trouble is to find it.

Boston, Mass. B. D. EASTWOOD.

Unusual Indicator Diagrams

In *Power*, Feb. 17, William Hampshire showed indicator diagrams taken from a compound engine. One diagram had been taken from the low-pressure cylinder when operating non-condensing; this is reproduced as Fig. 1.

Owing to the sudden failing of the vacuum the compression begins as soon as the piston starts on its

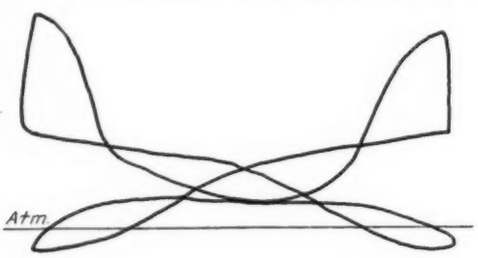


Fig. 1—Mr. Hubbard's diagram showing negative work

return stroke, with the result that, instead of the usual 7 or 8 lb. final compression pressure, it rises to 23 lb. The pressure, however, drops to the normal 8 lb. as soon as the admission valve opens and before the piston begins its working stroke. Consequently, except for a small section in the middle of the diagram, the whole of the area indicates negative horsepower.

The subject is much more interesting than appears in this particular diagram. Had experiments been made of varying the cutoff during this abnormal non-condensing working period, it would have been discovered that the longer cutoffs gave less negative work and shorter cutoffs more negative work. Had the speed been varied,

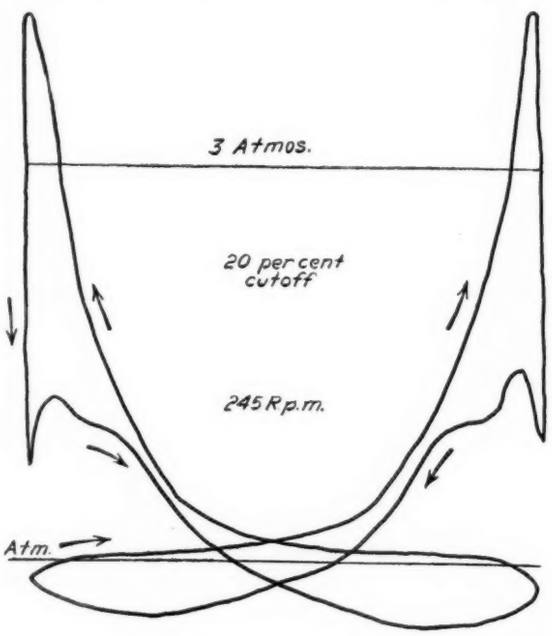


Fig. 2—Diagram from locomotive with throttle closed

the negative work would have decreased with slower speeds and have increased with higher speeds.

The diagrams in Figs. 2 and 3 will be found instructive in this respect, for the reason that stationary engineers seldom have occasion to experiment in a similar manner. For example, Fig. 2, which was taken from a simple express locomotive running with closed throttle without any steam, reproduces the effects shown in Fig. 1, but in an exaggerated degree, because the speed here is about 245 r.p.m., while in Fig. 1 it was possibly not much over 100 r.p.m. In Fig. 2 the cutoff is 20 per cent; had it been reduced to about 12 per cent, which I presume to be the cutoff when the diagram in Fig. 1 was taken, the compression would have been more exaggerated. The ultimate compression is about 60 lb. gage, but the initial pressure is only 30 lb.

In Fig. 3 the cutoff has been increased from 20 to 60 per cent, and although the speed has slightly increased, the negative horsepower work has been much reduced.

In diagrams from a locomotive similar in every respect to the one which gave Fig. 2 and Fig. 3 except that the cylinders are compound instead of simple with the cutoff only 40 per cent, the negative work area in the low-pressure cylinders was rather less than with 60 per cent cutoff in the simple locomotive. But in the

high-pressure cylinders, which acted as a species of auxiliary clearance-volume for the low-pressure cylinder, there was much more positive and effective work done than is due to the compressions alone in that cylinder.

In a similar manner it is possible that had the high-pressure card from the stationary engine been taken,

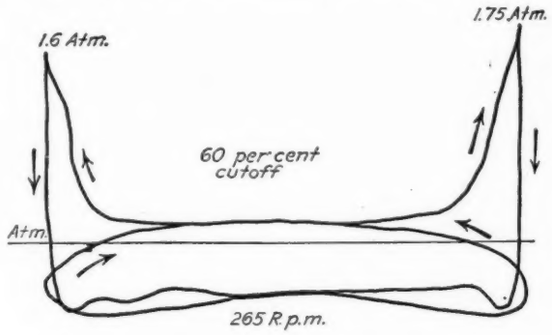


Fig. 3—Influence of lengthening cutoff

it would have been found that, in allowing for the higher back pressure, the high-pressure cylinder was performing more work than usual.

London, England. CHARLES R. KING.

Do Water-Cooled Furnace Walls Increase Boiler Efficiency?

I am interested in several statements in Mr. Harvey's article, "Do Water-Cooled Furnace Walls Increase Boiler Efficiency?" in the April 7 issue, particularly regarding the boiler test mentioned in the last paragraph, which showed that a change in baffling to reduce the area of heating surface in the combustion chamber to half its former value had "little effect on the total heat absorbed by such surface." More information on what was done and how the heat absorption was determined would be valuable to others contemplating changes in baffling. Not too much information is available as to the upper limit of heat transfer by direct radiation, and it is possible, in the test referred to by Mr. Harvey, that some relatively ineffective surface was eliminated and that the remainder had sufficient margin to make up for the absence of that baffled off.

While I have had no experience with furnaces of this type, I understand that experiments are under way with water-cooled walls fed from a separate measured source and evaporating into the steam line, so that one portion of the argument will be settled, but the following will indicate that there is something to be said for increased efficiency with water-cooled walls.

It is a matter of record that the reason for adopting water-cooled walls was that at fairly high ratings, as soon as the CO_2 reached a certain point necessary for the best economy by reducing the excess air to a minimum, the furnace walls began to drip and showed signs of rapid deterioration. A furnace was therefore built with the equivalent of the two side walls a continuous water-cooled surface, but, owing probably to structural difficulties of arranging headers to clear stoker mechanism, doors, etc., the front and rear walls were built of brick. It was expected that these might give trouble, but on putting the furnace into operation they did not do so even when operated at higher ratings and CO_2 values than before.

This would seem to indicate that, owing to the greater direct absorption of radiant heat, the furnace temperature had been reduced below what it was with all brick walls and consequently that the heat content of the gases, which had to be absorbed by convection in the tubes, would be reduced so that, assuming the same efficiency of absorption there, which could not be far wrong, there would be an increased total heat absorption in the boiler and furnace walls and consequently increased efficiency of boiler and furnace. If, as I understand, the CO_2 was higher on these tests than had been found practical to run with on brick-lined furnaces, although no directly comparable tests were published, the flue-gas loss would be decreased owing to the smaller weight per pound of coal carrying away heat. Therefore it does not seem unreasonable to assign at least part of the increased efficiency, along with the opportunity to develop the extremely high capacities shown in the Hell Gate tests, to the water-lined furnace wall construction—this not to be interpreted in any way to disparage the excellent performance of the stoker.

New Haven, Conn. H. D. FISHER.

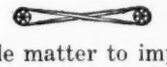
Will a Broken Discharge Valve in Air Compressor Cause the Temperature of the Air To Increase?

In the May 5 issue Frank Richards makes some interesting comments on my letter which appeared in March 24 issue, and his last sentence reads: "This suggests a new line of experimenting."

Quoting from my letter: "Finally the pipe seemed about straight and fairly cool, so the compressor was started. As soon as the air began to flow in the header, the temperature began to rise and upon opening a valve to the atmosphere, the flame rushed out like a blow-torch. We then turned on the reserve water supply to the condensers and began examining the compressor to locate the initial cause of the trouble."

As stated in my former letter, we found a broken discharge valve and replaced it with a new one, and the compressor was soon ready for operation again. No changes were made in the quality or quantity of oil used, neither was any removal of carbon deposits in pipes or receiver attempted at the time; in fact, nothing was done except placing a new valve for a broken one. When the compressor was started there was no sign of flame or blow-torch action and everything worked smoothly as usual. The average engineer, who happens to see a practical demonstration like that, will think, "The ingenious theory," handed down by his brother engineers from the strenuous days of The Croton Aqueduct, is very nearly right; until a "new line of experimenting" has actually proved its fallacy.

Little Rock, Ark. FRANK C. BLOMBERG.



It is often a simple matter to improvise a flow meter to meet some temporary need. In one case an indicator was needed by which the throttle valve on the scrubber spray of a gas producer could be regulated. An old steam gage was connected to a tee between the valve and the spray. Paper was pasted over the dial and the gage graduated as a flow meter. The calibration was done with the aid of a small open tank and a stop watch.

Questions and Answers

Conducted by

Franklin Van Winkle

Excessive Calking of Boiler Seams

What injurious effects may result from excessive calking of boiler seams? A. H.

Excessive calking with a flat-ended tool, for beating down the edge of the lap to form a thin calking edge, may impair the tightness of rivets, and excessive driving of the thin edge beneath the upper plate injures the texture of the material and may cause creasing or cutting into the lower plate sufficient to result in injury.

Water Contained by H.R.T. Boiler

How many gallons of water will be required to fill a horizontal return boiler 72 in. in diameter by 18 ft long, containing ninety-six 3½-in. tubes with the water level within 18 in. of the top of the shell? A. M. F.

The cross-sectional area of the space above the water line, neglecting braces, may be found by the formula for finding the area of a circular segment, namely,

$$Area\ of\ segment = \frac{4H^2}{3}\sqrt{\frac{2R}{H} - 0.608}$$

in which H = height of segment, in this case 18 in., and R = the radius, in this case 36 in.

Substituting these values gives

$$Area = \frac{4 \times (18)^2}{3}\sqrt{\frac{2 \times 36}{18} - 0.608} = 796\ sq.in.$$

The cross-sectional area of the tubes would be $3\frac{1}{2} \times 3\frac{1}{2} \times 0.7854 \times 96 = 923.6$ sq.in. As the gross cross-sectional area of the boiler is $72 \times 72 \times 0.7854 = 4{,}071.5$ sq.in., the net cross-sectional area of the space occupied by the water would be $4{,}071.5 - (796 + 923.6) = 2{,}351.9$ sq.in., and to fill that space would require $2{,}351.9 \times 18 \times 12 = 508{,}010.4$ cu.in. $= 508{,}010.4 \div 231 = 2{,}199$, or practically 2,200 gal. of water.

Equalizing Draft of Boilers

Our boiler plant consists of three horizontal return tubular boilers set in battery. Each boiler has a 48 x 16-in. smoke uptake that discharges into a 48 in. diameter stack connection which passes over the fronts of the boilers. We frequently are troubled with poor draft for one or another of the units, especially if some other boiler of the battery is operated with forced draft. How can the drafts be equalized? P. C.

For best draft conditions all junctions of the uptakes with the stack connection should be made with easy bends, so the flow of the gases may be smooth and without eddies, just as would be most favorable to the flow of water. To secure equalization of the drafts, each boiler uptake, except the one farthest from the stack, should be provided with a baffle to so direct the course of the gases that, when delivered into the main connection, their flow will be toward the stack before coming in contact with gases discharged from other boilers. Then the gases discharged from a boiler uptake with stronger draft will exert a jet-pump action rather than offer an obstable to the discharge from the others. Of course each baffle must not obstruct the main connection more than the proportion of cross-sectional area to which its uptake is entitled.

Breakage of Gage Glasses from Scratching

What is the theory for a glass gage flying into bits when cleaned with a metal rod? W. L. E.

When glass tubes are formed, they are likely to crack upon becoming cool, from ununiform contraction, and even when cooled slowly in the process of annealing, breakages may afterward occur from unequal expansion of the material. When scratched by an iron rod or other material harder than the glass, in addition to a mere furrow, the tearing of the material is accompanied by fractures which are extended into the glass by disturbance of the material from vibration, or unequal expansion from added heat or heat developed by the scratching operation. Glass is highly elastic, and when scratched there is sudden release of part of its tensile strength from cleavage, and the forces of repulsion due to expansion from heat or compression during crystallization cause the tube to fly apart as though split by wedges driven at intervals into the furrow. It is this extension in depth of the fractures that is utilized for breaking glass by vibration or bending when a glass cutter is used; or when complete cleavage is obtained by unequal expansion from passing a hot iron along the scratch or furrow.

Filtering Muddy Feed Water

Our boiler-feed water, obtained from a small stream, is of good quality except after times of heavy rain, when the water is muddy. What means can be taken to obtain clear water without an elaborate filtration system? L. B.

Clean water can usually be obtained by sinking a well 30 to 50 ft. from the side of the stream using the banks as a filtering medium. To insure a good supply of water, the bottom of the finished well should be several feet below low-water mark of the stream. Where the banks are composed of clay or soft earth, the well should have a tight curb extended down to a natural gravel bed, or if this is not present, the excavation should be deep enough to receive a bottom of small stones and gravel two or three feet thick, above which the wall should be tight to prevent mud from washing into the well. Another method is to build a water box to one side of the stream two or three feet below lowest water, with the top higher than the highest water and connect the box with the stream by a walled trench also carried above high-water level, and filled with small stones and gravel.

A.S.M.E. Holds Spring Meeting at Milwaukee

AN UNUSUALLY large attendance of over eleven hundred, an attractive program, an active local committee and generous co-operation by the local manufacturers in opening their plants for inspection, together with the Mid-West Power Show, were all factors in making the Spring Meeting of the American Society of Mechanical Engineers, (Milwaukee, May 18-21), one of the most successful in the annals of the Society.

Space does not permit a detailed report of the varied program, and abstracts of only those papers and discussions on strictly power-plant subjects are included. Some of the papers will be printed more fully in subsequent issues.

That the time has arrived for a closer study of what actually takes place in the process of combustion with pulverized coal and its relation to furnace design, was emphasized by the character of the three papers presented at the Pulverized Coal Session on Tuesday morning.

According to Prof. A. G. Christie, experience has shown that it is important to transfer as much heat as possible by radiation, hence maximum furnace temperatures are desirable. The rate of absorption by radiant heat is eight to ten times that by convection, data now at hand indicating that the furnace radiation may reach as high as 75,000 B.t.u. per square foot per hour to metal side walls. In the case of brick-lined furnaces the heat is reflected and much is absorbed by the gases from which it is given up by convection at a relatively lower rate in the passes of the boiler.

Another reason for a closer study of the radiant heat is the fact that certain gases, such as carbon dioxide and water vapor, have the property of both absorbing and emitting radiant heat, in contrast to oxygen, nitrogen and air, which are practically inert as radiators or absorbers.

Professor Christie advanced the theory that the cooling effect of water-cooled walls would be appreciable only on the outside envelope of the furnace gases, as the particles of burning carbon and incandescent ash form obstacles to radiations from the interior portions of the flame and either absorb or reflect these radiations. Where less cooling by the side walls is desirable, such as when burning anthracite, he suggested calorized tubes, inasmuch as gray surfaces are better reflectors and poorer absorbers than black surfaces.

That the theory advanced by the author had not been borne out in practice was apparent from the discussion by C. G. Spencer, who related experience with water-cooled furnace walls at Cahokia. In a boiler equipped with a furnace of this type which has been in continuous service for about eight weeks, a marked decrease in furnace temperature was noted. This decreased temperature made it necessary to add another row of tubes to the interdeck superheater in order to maintain the superheat. However, no slagging has occurred when operating at a CO_2 higher than can be carried with a non-water-cooled furnace, and there has been no fouling of the metal. Moreover, the draft drop through the boiler was noticeably less because of the reduced gas volume—a direct result of the higher CO_2. This permits operating at a higher rating with the same stack draft.

William L. Abbott, Presidential Nominee

Experiences with low-grade Middle West coals, according to Professor Christie, show that air-cooled furnace walls are washed away rapidly by the chemical alloying properties of liquid ash containing a large percentage of iron oxide. Such walls become effective only when the brick have washed down to a thickness ranging from ¾ to 2 in. This would indicate that silica-alumina brick can be used in air-cooled walls only when the ash has a high fusing point.

In discussing Professor Christie's paper, H. W. Brooks stressed the mixing of the gases in the furnace. To illustrate the importance of this, he compared the carbon particle, such as would pass a 200-mesh screen to the airship "Los Angeles" surrounded by over twelve billion oxygen atoms each the size of a gnat. Complete combustion necessitates the disintegration of this coal particle into billions of pieces, each combining with its corresponding gnat-sized oxygen atoms.

Mr. Brooks followed with a description of the Fuller well-type furnace in which turbulence is secured by tangential burners setting up a so-called tornado effect. Above this well is a dispersion chamber in which the hot gases are permitted to expand before reaching the boiler tubes and thus avoid any erosive effect. This furnace will be discussed in a later issue of *Power*.

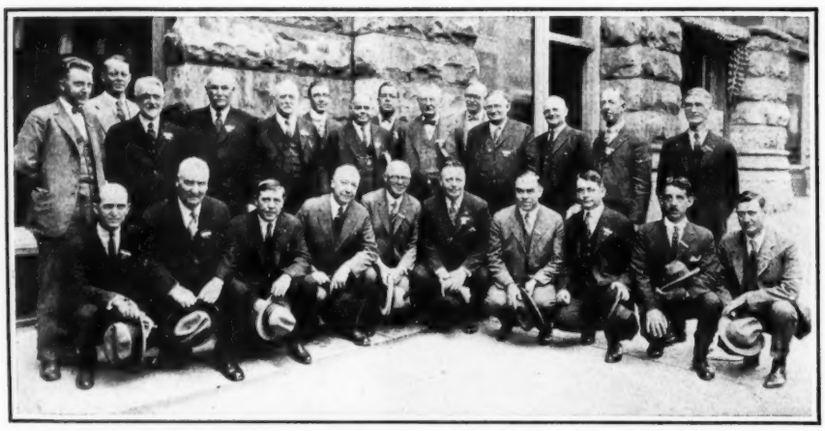
A further discussion of the paper was offered by C. W. E. Clarke, who pointed out that the total surface in the boiler measured in terms of its effectiveness—that is, considering surface exposed to radiant heat as more effective than that exposed only to "convected" heat—must be the same for a given output whether the walls be air or water cooled. This surface must be properly distributed between the two classes of work just mentioned. If the gases entering the first pass are at the same temperature for both air-cooled and water-cooled side walls, then the amount of surface in the upper parts must be the same per pound of gas passing through the boiler. However, it is evident that if a considerable amount of heat be absorbed by surfaces in the furnace walls, the furnace temperature must be materially reduced or else there must be more heat produced in the furnace to offset the radiant-heat absorption. The temperature of the gases in the first pass will be reduced with water-cooled walls, but owing to this lower temperature the mean heat transfer per unit of area in the boiler proper will be reduced. It is probable that to get the same temperature of exit, nearly the same length of gas travel in terms of surface passed over will have to be provided.

Tests made on boilers in the Colfax station, operating with preheated air, showed that, though the furnace temperature was measurably increased, the exit gas temperature was reduced, an indication that at least with temperatures of the order of 2,800 to 3,200 deg. F. higher temperatures result in more efficient working of the boiler furnaces. The efficiency of the "convection" surfaces will be reduced perhaps sufficiently to offset it.

The whole matter may be summed up, according to Mr. Clarke, by a consideration of the fundamental fact that the relative efficiencies of two boilers may be measured by the temperature of their exit gases, assuming for comparison the same generated temperature in the furnace.

The second paper of this session, by Prof. W. J. Wohlenberg and D. G. Morrow, dealt with a mathematical analysis of radiation in the pulverized-coal furnace. It was shown that the radiating power through the flame depends primarily on the size of the particle and, based on the flame surface area, its magnitude relative to black radiation is low. The heat-absorption intensity at the cold surface, however, may be considerably higher than the relative radiance of the flame. This factor depends upon both the amount and the disposition of the refractory furnace lining. George Orrok, who, in the absence of the authors, presented the paper, suggested an empirical formula that closely checked with the rational formula developed in the paper for determining furnace proportions.

B. N. Broido, in a written discussion, pointed out as one difference between theory and practice the tendency to overlook the radiant effect of the gases themselves. This he considered of more importance than the size of the coal particles to which the authors gave so much attention. Experiment has shown, he said, that CO_2 and water vapor may radiate heat, and this should have its influence on furnace and boiler design, as such radiation is most effective at high temperature and low gas velocities. Mr. Broido felt that large furnace volumes were important not only for complete combustion, but for maximum absorption of radiant heat.



National Board of Boiler and Pressure-Vessel Inspectors at Milwaukee

Front Row: J. D. Newcomb, Jr., Little Rock, Ark.; George Wilcox, St. Paul, Minn.; C. O. Myers (secretary), Columbus, Ohio; D. M. Medcalf, Toronto, Can.; Fred R. Low, New York City; Charles E. Gorton, New York City; Joseph F. Scott (president), Trenton, N. J.; James E. Speed, Erie, Pa.; John Forgeng, Scranton; L. M. Barringer, Seattle.

Second Row: A. L. Daniels, Parkersburg, W. Va.; L. C. Peal, Nashville, Tenn.; C. L. Huston, Coatesville, Pa.; William P. Eales, Hartford, Conn.; E. W. Fitt, Omaha; William H. Furman, Albany, N. Y.; H. E. McBryde, Tulsa, Okla.; L. R. Land, Oklahoma City, Okla.; W. J. Ranton, New York City; H. H. Mills, Detroit; E. W. Farmer, Providence, R. I.; John M. Lukens, Philadelphia; C. D. Thomas, Salem, Ore.; Charles J. Manney, Columbus, Ohio.

Testing Fineness of Coal

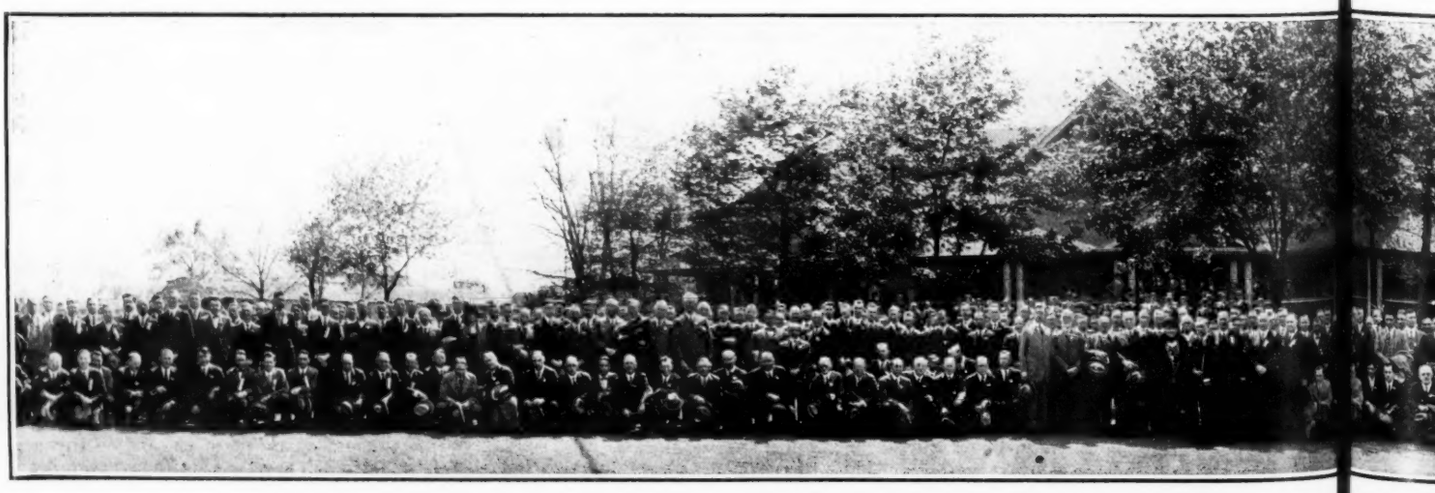
That screen tests for fineness may be misleading in making comparisons of pulverizing mills, was brought out in a paper by L. V. Andrews, on "A Microscopic Study of Pulverized Coal." The author's investigations indicated that the standard 100-mesh and 200-mesh percentage method of testing pulverized coal is at fault and that a microscope should be consulted or a more elaborate screen test run where it is desired to know exactly what quality of pulverized coal is being delivered.

The discussion on this paper, while agreeing as to the inadequancy of the usual method, owing to different coals breaking up differently, seemed also to doubt the value of the microscopic examination because of the difficulty of getting the results of even experienced examiners to check closely.

Hydro-Electric Session

At this session on Tuesday morning W. M. White, chief engineer, hydraulic department, Allis-Chalmers Manufacturing Co., delivered an interesting paper dealing with "Mechanical Problems of Hydraulic Turbine Design." Taking as a concrete example the 70,000-hp. unit recently put into operation at the plant of the Niagara Falls Power Co., the author discussed in order the problems connected with the flow of the water through the casing, the guide vanes, the runner and the draft tube and finally the mechanical transmission of power and its governing. In the design of the plate-steel spiral casing for this machine the greatest problem met with was the driving of the 1⅜-in. rivets, 6¾ in. long, through the flange of the speed ring and the double thickness of plate and also the driving of the rivets at the lap joints of the larger section of the casing. For the purpose a special bull riveter was used having a reach of 108 in., adjustable to any required angle by means of air motors, and capable of exerting 150 tons with 100 lb. air pressure.

Guide-vane construction was discussed at some length. For moderate- and high-head plants having outside gate mechanism, cast-steel guide vanes are used universally, but in low-head plants having outside gate mechanism plate-steel guide vanes are preferred owing to the economy of their use and because of the flexibility and malleability of the plate, permitting it to be brought back to proper shape when distorted. In the runner, its shaft and bearings, difficult problems were introduced by the enormous forces generated



Visiting members of the A.S.M.E., A.S.R.E. and N.A.S.[illegible] at the wo[illegible]

by a water pressure of 100 lb. per sq.in. over the large surfaces of the machine. Other features given prominence were the renewable pitting plates at the discharge edge of the runner, the plate steel hydraucone, the guide bearing and its oiling system, the governing mechanism and the enormous butterfly valves at the upper end of the penstocks, which have a diameter of 23 ft. 6 in. and are designed to withstand a total force of 1,250,000 pounds.

In the discussion of the paper H. B. Taylor agreed that plate-steel casings might be used where the forces were too great for spiral concrete casings, but cast-steel casings were to be preferred, owing to longer life and less leakage because of the closer fitting. In units of large size where the head was high, cast-steel casings were desirable regardless of the higher cost. Mr. Taylor emphasized the importance of close clearances between guide vanes and working parts, and the use of circular disks to block off part of the leakage space. Attention was directed to the danger from breakage of cast-iron guide-vane links. Rack spacing for the larger installations should be conservative, as the increased size of the wheel had nothing to do with it. The great value of filling the void space below the runner to eliminate vortices and disturbances was emphasized and reference made to the development of cone construction. As a turbine governor medium, water treated with potassium bichromate had been used to advantage in place of oil.

Referring to the emphasis placed on wide trash rack spacing for high-speed units owing to the larger space in the runner, L. F. Harza asked if the regulating gates were not the factor determining the spacing. It was noticeable that guide vane openings bore a higher ratio to runner spacing than in older type machines. It was pointed out that increasing the size of the unit was no reason for larger rack spacing. The latter was a two-dimension proposition and in the wheel three dimensions must be considered. Enlarging the rack spacing simply increased the mechanical strength of the piece that could go through and in the same proportion endangered the machine.

E. A. Dow, in a paper, "Mechanical Features Affecting the Reliable and Economical Operation of Hydro-Electric Plants," dealt with the subjects of flashboards, trash racks, rack rakes, sluice and headgates, penstock valves, air vents and discharge-measuring devices, from the viewpoint of economy and reliability of operation, based on the New England Power Co.'s practice. Reducing head losses and leakage and adhering to strength and simplicity in the design of hydraulic equipment was stressed. Mr. Dow emphasized the necessity of devices for measuring and recording the quantity of water to hydraulic turbines and said that "nothing is more important to economy of operation than complete and trustworthy water records and a convenient and reliable method of checking the performance of hydraulic turbines."

H. L. Doolittle agreed with the decision recounted in the paper to use valves at both the top and bottom ends of the penstocks. It was essential to have a valve at the bottom of the line during periods when the turbine was out of service and a valve at the top made it possible to unwater the penstock for inspection or shut off the flow in case of accident to the penstock. As a source of danger remote control of the valves should not be permitted. The speaker was gratified to see the development in instruments for hydraulic plants. Meters to give a continuous record of the water to the wheel were highly desirable. By giving a continuous check on operating efficiency,

Left to right—Fred R. Low, past-president A.S.M.E.; Robert Cramer, secretary local executive committee, spring meeting of A.S.M.E.; Prof. William F. Durand, president A.S.M.E.

Photo taken in the works of Nordberg Manufacturing Co., Milwaukee, Wis. In the background is a 1,250-hp. Diesel engine for the Community Power & Light Co., Humboldt, Kansas.

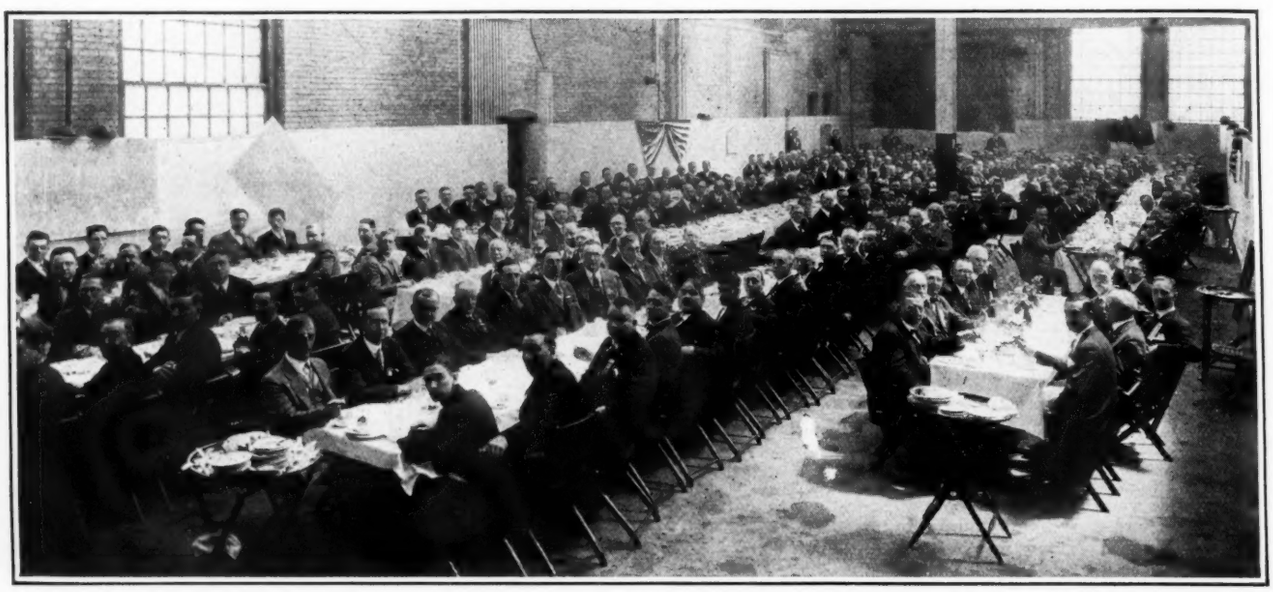
...A.S.E. at the works of the Allis-Chalmers Manufacturing Company

they indicated when needles and nozzles were worn and the need for overhauling.

R. V. Terry made mention of the reduction in capacity caused by the clogging of trash racks and the desirability of the mechanical rake to eliminate this difficulty.

Prof. R. W. Argus commented on discharge measuring by venturi meters. By computation he had found the author's coefficients a little high. Notwithstanding the fact that venturi meters were supposed to be accurate only where the entrance was smooth, the paper had shown that the venturi meter can be used with satisfaction even where there is a considerable degree of turbulence.

W. M. White commented on the fact that hydraulic plants had not been operated at the highest efficiency. Load dispatchers were dominated by maintenance of service more than by considerations of economy. He was glad to see the measuring device brought to the fore by Mr. Dow, as it would give the management the facts on the power developed with a given quantity of water and assure more efficient operation.



Nordberg Manufacturing Co. entertains 350 engineers at lunch during inspection of its plant in Milwaukee

Hydro and Steam Plants

In a paper, "The Parallel Operation of Hydro and Steam Plants, Some Operating and Economic Features that Should Receive Careful Attention," F. A. Allner outlined how a hydro development that is not equipped with seasonal storage can render the greatest demand service to a given system load if, on the days of greatest steam demand on the system coinciding with minimum flow, the hydro plant supplies the peaks and the steam plant the base of the system load. The greatest energy contribution from the hydro plant is obtained by letting it carry the base portion of the system load during high flow and having the peak portion produced by steam. General and specific methods were explained by which these economic principles are put into practice and particulars given of a system of load signaling by means of small changes in frequency above or below normal, which has been found useful for a better distribution of load during certain hours when it is otherwise difficult to secure the desired division of generation.

Particulars were given of a proposed ideal hydro-steam parallel operation where the steam station will be located immediately adjacent to the hydro plant. The generating units of both plants will be operated from the same control board. Circulating water for the condensers will be drawn from and returned to the forebay of the hydro plant. During frazil-ice attacks this arrangement is expected to minimize capacity reductions at the hydro plant. There is a natural seasonal diversity in the time of overhauling work at the two types of plants. It will be possible to keep the same skilled labor force employed more steadily throughout the year and to use the same shop facilities for the repair work of both plants.

Discussion on Mr. Allner's Paper

By bringing out the relation that exists between water and steam plants, Prof. A. G. Christie thought the paper of great value, in particular as the public generally did not realize the increasing cost of production from low-flow plants. In steam plants like Holtwood, operated in conjunction with a hydro-electric plant, it was difficult to estimate the use of the steam-plant equipment and the method of operation, as each plant differed. The refinements it would pay to install in the auxiliary steam plant depended directly on the use factor.

C. W. Place agreed that the peak-load service by the hydraulic plant was of the greatest importance in these combination stations. There were few hydraulic plants that could not be operated as at Holtwood. Steam operators did not appreciate the quickness with which hydraulic equipment could be brought into service and the effect on reducing the coal consumption throughout the entire period. It was the reduction of the total coal, rather than high economy at specific periods, that counted.

In this combination method of operation, C. B. Hawley stated that seasonal storage would be required. The cost of development was so great that usually it must be spread over two or more plants, and for the greatest economy the river should be developed as a whole, with the seasonal storage at the headwaters. The speaker presented a curve for a specific case showing how much hydraulic power was required to reduce the load on the steam plant to a given amount, which might serve as a guide in proportioning hydraulic developments.

N. E. Funk was of the opinion that the figures on the use of water power could not be taken from one combination and applied to another, as the larger the load the shorter the peak, and vice versa. The problem depended on the amount of power used and on the load conditions existing in any specific installation.

A. Pfau decried the practice of tabulating bids on hydraulic equipment and letting price determine the selection, as the character of the machinery was not expressed in the tabulation. It was poor economy to buy the cheapest equipment.

W. M. White was gratified to see the statement of the author giving the availability factor for waterwheels as 99.5 and 92.5 for steam plants. That initial cost was not the only factor that should enter into a decision between water and steam power, might be inferred from the fact that a 70,000-hp. hydraulic unit did away with the services of 200 men required in the mining, handling and firing the amount of coal for this output.

N. E. Funk thought that too much stress was being placed on present

economies and not enough consideration given to the future, such as conserving the coal resources.

Steam-Power Session

Five papers constituted the program for the Steam Power Session on Thursday. The first, by Professor Christie, on "Lake Waters for Condensers," called attention to the stratification of warm- and cold-water layers in northern lakes and other deep waters. Inasmuch as the cold bottom layers make excellent cooling water for condensers, permitting operation at high vacuums throughout the year, the author suggested that engineers give this careful consideration both in the selection of plant sites and in the design of intakes.

It developed in the discussion that experiences with water-works intakes at Chicago, Toronto and Cleveland had disclosed that subsurface currents make the prediction of these temperatures difficult and to avoid this it is necessary to extend the intakes considerable distances from shore. The large cost thus involved might more than offset the gain in operating efficiency. It was further brought out that such intakes must have very low entrance velocities to avoid a vortex in which water would be drawn from near the surface.

Advocates Use of High-Back-Pressure Turbine

With the development of standard high-pressure boilers has come an opportunity to employ the high-back-pressure turbine in plants using large quantities of steam for heating and process work at comparatively high pressures. Such an installation in the rubber industry at Akron was described by Hans Dahlstrand in his paper on "A Review of Steam Turbine Development." This particular unit, although taking steam at only 250 lb., exhausts at 100 lb. for process steam.

In view of successful applications of such turbines the author believed the idea might be advantageously applied to the remodeling of existing plants. In such cases it would be necessary only to install new boiler-room equipment operating at higher pressure and temperature and a high-back-pressure turbine exhausting into the existing lower-pressure header system. On this basis he presented curves showing the increase in efficiency of such a combined unit over an existing unit for various steam conditions.

Mr. Dahlstrand also touched upon materials for use with higher temperatures and pressures, pointing out that cast iron is no longer used for temperatures over 500 deg. He believed that heat-treating of cast steel is desirable for the high-pressure cylinders or other parts when designed for 700 deg. service, and that annealing cast-iron parts of the major sizes of turbines is warranted. He included some curves showing the results of investigations made by the Allis-Chalmers Co. on various metals and the characteristics that should be possessed by a metal suitable for use at 1,000 deg. F.

In discussing Mr. Dahlstrand's paper, J. M. Johnson expressed some doubt as to the application of the high-back-pressure turbine to the improvement of existing plants. He believed the opportunity for improving existing plants lay more in the installation of improved boilers and furnaces, increased steam pressures and temperatures with existing available equipment and possibly the further application of the regenerative principle by the addition of a turbine supplying bled steam for heating the feed water for the plant. He was of the opinion that the installation of high-back-pressure turbines supplying steam for process work has many possibilities, depending, of course, upon the steam demand and the price at which current can be purchased.

Alfred Iddles indorsed the use of the high-back-pressure turbine in industrial plants using steam at comparatively high pressures for process work and cited further some cases in the textile industry where an unbalanced steam and electrical demand had been met by the installation of both condensing and back-pressure turbines.

Professor Christie, while indorsing Mr. Dahlstrand's suggestions regarding the adaptability of the high-back-pressure turbine to industrial plants using process steam at relatively high pressures, did not share the latter's views as to the field in remodeling existing plants. Such a proposal involves the reconstruction of the boiler plant for the higher pressures. Most engineers, if given such an opportunity, would probably want larger boilers with higher settings which, in turn, would involve building alterations running into considerable expense. This might make it more desirable to build a complete new high-pressure section for base-load service, holding the older part of the plant in reserve for stand-by or peak-load service.

With respect to auxiliary turbines the speaker believed that there are many places in the plant where a highly efficient auxiliary turbine could be used, as it does not seem good engineering to install highly efficient plant equipment throughout and then add an inefficient auxiliary turbine that will be in constant use.

Performance at Lakeside

Comparison of theoretical possibilities and actual performance at the Lakeside Station, Milwaukee, was made in a paper by M. K. Drewry for a period of best economy, Oct. 10 to Nov. 10, 1924. An abstract of this paper appeared in the May 26 issue of *Power*.

Lack of time prevented oral discussion of Mr. Drewry's paper, also that of W. L. DeBaufre on "Analysis of Power-Plant Performance Based on the Second Law of Thermodynamics."

The remaining paper of this session dealing with "The Rational Design of Covering for Pipes Carrying Steam up to 800 Deg. F.," by W. A. Carter and E. T. Cope, both of the Detroit Edison Co., has already appeared in *Power* (see May 19 issue).

Performance of Large Pumping Engines

The results of duty tests on three vertical triple-expansion pumping engines at the Riverside Pumping Station, Milwaukee, were presented by Charles A. Cahill before the Milwaukee section on Tuesday evening. Two of these units are for high-head service, 280 ft., and the third operates against a head of 170 ft. Having a guaranteed capacity of 22 million gallons per day, the first two units operating at 200 lb. steam pressure, 516 and 507 deg. F. at the throttles, and vacuums of 28.58 and 28.93 in., developed, respectively, duties of 214.55 and 213.27 million foot-pounds per 1,000 lb. of steam. This is equivalent to 176.16 and 176.17 million foot-pound per million B.t.u.

This type of engine, the author explained, was selected because of its reliability, high economy and low maintenance cost. Some question was raised in the discussion of the paper as to the extra cost of this type over the turbine-driven centrifugal pump, in answer to which Mr. Cahill stated the preliminary studies had shown that for under 3,000 hours operation per year the centrifugal would have been more economical and above this the triple-expansion engine.

One of the most interesting papers of the meeting was that on the X-ray examination of steel castings by I. E. Moultrop and E. W. Norris. This related, with the aid of numerous slides, the X-ray examinations that were made at the Watertown arsenal on the castings for the 1,200-lb. Weymouth turbine. Mr. Norris, who presented the paper, explained that in all some thirty castings were examined. Out of these only five proved seriously defective, the remainder being for the most part of high quality. Through the use of the X-ray, it was possible to eliminate castings that would have been unequal to the service because of flaws invisible from the surface. Moreover, the observations made form an excellent basis for further study of the materials in this installation as affected by conditions of service. A more complete abstract of this paper, together with the X-ray photographs, will be printed in a later issue. It was brought out in the discussion that the use of the X-ray also tends to improve the technique and thus reduce foundry losses. Moreover, it provides a means for progressive studies of metals during periods of actual operation.

Another paper that created considerable interest and furnished valuable test data was the report of a test on a four-cylinder. high-speed, vertical Ames unaflow engine at various loads, two different steam pressures, two different back pressures and with both saturated and superheated steam. A water rate of 20.1 lb. per hp.-hr. was obtained when operating at 125 lb. steam, three-quarter load (300 kw.) and atmospheric exhaust. The results of these tests appeared in the May 19 issue of *Power*.

San Francisco was selected for the next spring meeting, and the nominating committee reported the following ballot: President, W. L. Abbott, of Chicago; vice-presidents, A. G. Christie, Baltimore; Wm. T. Magruder, Columbus, Ohio; R. V. Wright, New York. Managers—R. L. Daugherty, Pasadena; Wm. Elmer, Altoona; C. E. Gorton, New York. Treasurer — Erik Oberg, New York. Delegates to American Engineering Council—W. L. Abbott, J. F. Paige, A. M. Greene, Jr., J. L. Harrington, Ira N. Hollis, S. H. Libby, D. S. Kimball, W. B. Powell and H. L. Thompson.

Refrigerating Engineers Meet at Milwaukee

FROM May 20 to 22 inclusive, the American Society of Refrigerating Engineers held its twelfth Western meeting in Milwaukee, Wis., with Hotel Wisconsin as headquarters. The meeting was simultaneous with the spring meeting of the American Society of Mechanical Engineers, so that a joint session on the Test Code for Refrigerating Systems was arranged. The refrigerating engineers also had the opportunity of inspecting the Midwest Power Show. Registration showed an attendance approximating 70.

At the opening session Wednesday morning devoted to business, there was some discussion as to the possible publication of a data book including the latest steam tables and the refrigerating tables now given preference. Research on corrosion problems had been made possible by a subscription of $3,000 and work had already started at the Massachusetts Institute of Technology, so that a report of progress giving some definite results would be made at the annual meeting.

President Greene's Address

In his presidential address, Van R. H. Greene reviewed refrigerating practice of twenty years ago and the revolutionary changes that had taken place. Scarcity of labor, the higher wage and the higher cost of coal and materials had been largely responsible for the improvement in the design of the equipment and the introduction of labor-saving devices for the handling of the product. With all this activity by designers to improve the efficiency of the plant as a whole, no commensurate thought had been given on the part of plant owners to the management of their properties, a factor that seriously affects the results from any plant. The president made a special plea to members of the society that they take more interest in the question of plant operation and management.

Papers Presented Wednesday Afternoon

Three papers were presented at the afternoon session. The first, by C. W. Cutler, on "Flywheel Requirements for Unbalanced Air and Ammonia Compressors," was received with great interest. At the spring meeting a year ago, Dr. Stevenson delivered a paper on "The Flywheel Problem in Compressors Direct-Connected to Synchronous Motors," in which he gave a set of curves for the purpose of rapid and accurate calculations of current pulsation. This paper was restricted to treatment of compressors having duplicate cylinders and to conditions of balanced pressures. As a sequel the present paper was prepared to present the general solution of the problem and to supplement the curves of Dr. Stevenson with ones that applied to compressors operating under unbalanced conditions.

The paper was divided into five sections, discussing in order, past methods of flywheel calculation, practical problems that may occasion a compressor to be unbalanced, studies of fundamentals involved in the short methods of calculation, a set of curves for the calculation of current pulsations and a suggested method for the approximate measurement of current pulsation without the use of the oscillograph. Discussion of the paper turned to the different factors that might enter into current fluctuation and the effect on the curves presented. It was recognized that there would be different current fluctuations for 40- and 50-deg. motors, less flywheel effect being required with the 50-deg. motor.

In a paper on "Commercializing the Small Synchronous Motor for Direct Connection to Compressors" Theodore Schou discussed for the most part the overhung motor for the direct driving of duplex single-acting compressors, and single-cylinder double-acting compressors. Data were given on flywheel and horsepower requirements, motor foundations, floor spacing and erection, with comments on inherent characteristics and control and comparison with the standard synchronous motor and the belted induction motor.

Discussion developed on the possibility of maintaining a uniform air gap when the bearings wore down and the possible neutralizing of some of the saving in copper by the fanning of air into pockets between the poles.

In the third paper, on the "Design and Methods of Construction of Shell and Tube Type Ammonia Condensers," L. H. Burkhart gave a detailed analysis of the design of a 100-ton condenser, discussing tube length, diameter and layout; the thickness of the shell and the tube sheet, the size of the water-box, the arrangement of the distributor and the methods of manufacture and testing. The author was decidedly in favor of electric welded joints. When the joint is made in a first-class shop, he considered it as safe as any other type of joint.

In the discussion the author was asked, if, in welding, the whole shell was reheated to take out the stresses. Mr. Burkhart considered reheating a real detriment. The weld was best the way it came from the arc. Some discussion followed on the velocity of flow through the tubes and the coming off temperature of the water which should bear a certain relation to the temperature corresponding to the head pressure. In atmospheric and double-pipe condensers, it was pointed out that the differences in these temperatures were 5 deg. or less, whereas in the shell and tubular types the difference was at least double this figure. This was accounted for by the accumulation of non-condensable gases. Purging would relieve this trouble and improve results from the condensers.

Thursday Morning Session

Two papers were presented at the morning session on Thursday, one on the "Modern Trend in Applying Ozone to Cold Storage," by F. E. Hartman, and the other on a "Complete Automatic 50-Ton Refrigerating Plant for Processing Cotton," by F. L. Fairbanks. In the former paper Mr. Hartman went into detail on the theory of ozone in cold storage, reviewed past practices together with what had been accomplished with ozone, emphasized the importance of quantitative treatment and summarized commercial apparatus, describing in particular the new tubular ozone generator. This machine eliminates edging effects, or the creeping of the discharge beyond the boundaries of the electrodes, which results in considerable sparking. With a machine of the tubular type of quality of ozone produced can be determined accurately and the proper amount maintained for the specific service in question.

Discussion on the paper turned to the effectiveness of ozone in reducing the so-called storage flavor. In the case of egg storage an effort was made to keep the concentration to 1 to 1½ parts of O_3 per million parts of air by weight. It was pointed out that an ample volume of air properly distributed was the key to the success of egg houses. With the use of ozone the amount of air supplied could be curtailed and it was possible to carry higher humidity which would result in less shrinkage.

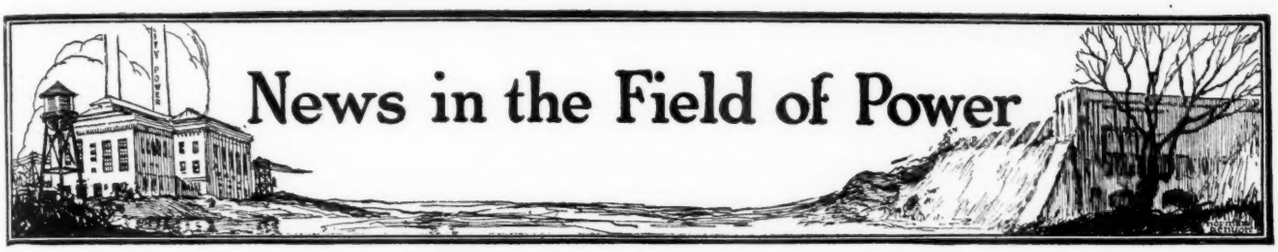
F. L. Fairbanks, in the second paper of the session, described a complete automatic 50-ton refrigerating plant for processing cotton. The machine consists of a series of devices for treating cloth chemically in such a manner as to convert the cotton fiber into a cellulose tube or thread and compressing or flattening these while at a comparatively low temperature, the result being to produce from ordinary cotton sheeting a smooth basket-like weave resembling linen which, when dyed with various colors, is marketed as dress goods. Full details of the refrigerating plant, the various controls and the scheme of operation were given. The discussion was brief, being limited to the location of the thermostat for preventing a freeze-up of the system.

Other papers of the meeting were: "The Mechanically Refrigerated Ice Cream Cabinet," by C. E. Haven, and "Household Refrigeration and Research Work," by C. C. Spreen.

Thursday Afternoon Session

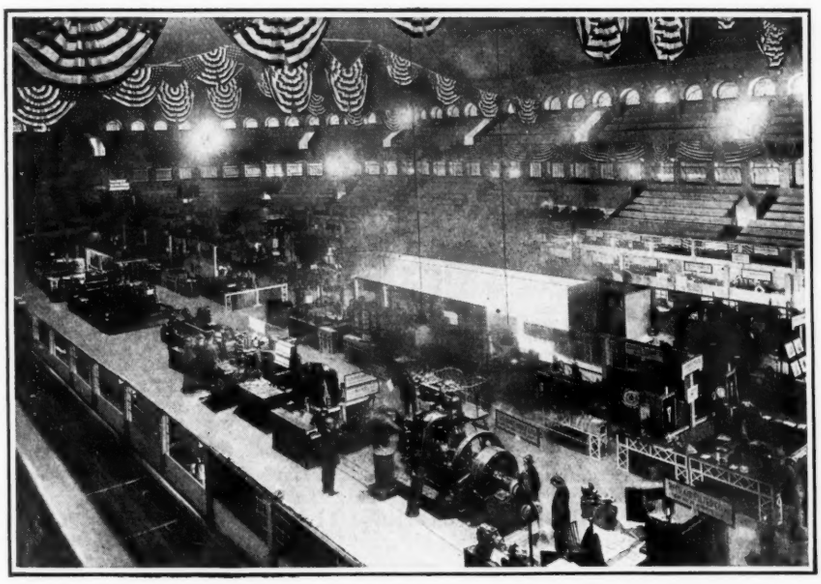
Thursday afternoon was devoted to a public hearing on the Test Code for Refrigerating Systems as prepared by a joint committee of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. The code was in type in tentative form and was gone over carefully at this session. Changes were suggested in some of the phraseology, particularly where the requirements seemed to make certain methods of measurement mandatory, with suggestions for supplemental paragraphs in connection with two-stage compression. It was pointed out that the tables had been made particularly complete so that there would be a place for the data obtained from any of the various methods of measuring that might be used.

Throughout the convention suitable entertainment was provided for the ladies, inspection trips were arranged for the engineers and time allotted for a visit to the Mid-West Power Show held in Milwaukee.



Midwest Power Show Exhibits Exceptionally Attractive

THE Midwest Power Show held in Milwaukee from May 18 to 21 inclusive broke all records of the Middle West as an exhibition of power-plant equipment. Booths to the number of 400 and 200 exhibitors tell the story. All available space on the main floor of the auditorium, including the main arena and three smaller halls, was occupied. The exhibits were tastefully arranged and the general ensemble was particularly attractive. Manufacturers vied with one another in displaying the latest and best of their products and special effort was made to improve the educational value. For example, local manufacturers co-operated by placing working prime movers on the floor specially fitted for observing the construction and the operation, and there were a large number of working models and sectional cuts through stationary equipment. Steam engines and turbines, oil engines, typical waterwheel runners, ice machines, pumps, coal pulverizers, stokers, conveyors, screens and other large equipment were in evidence, and there was great diversity in all the smaller apparatus and products used in the power plant.

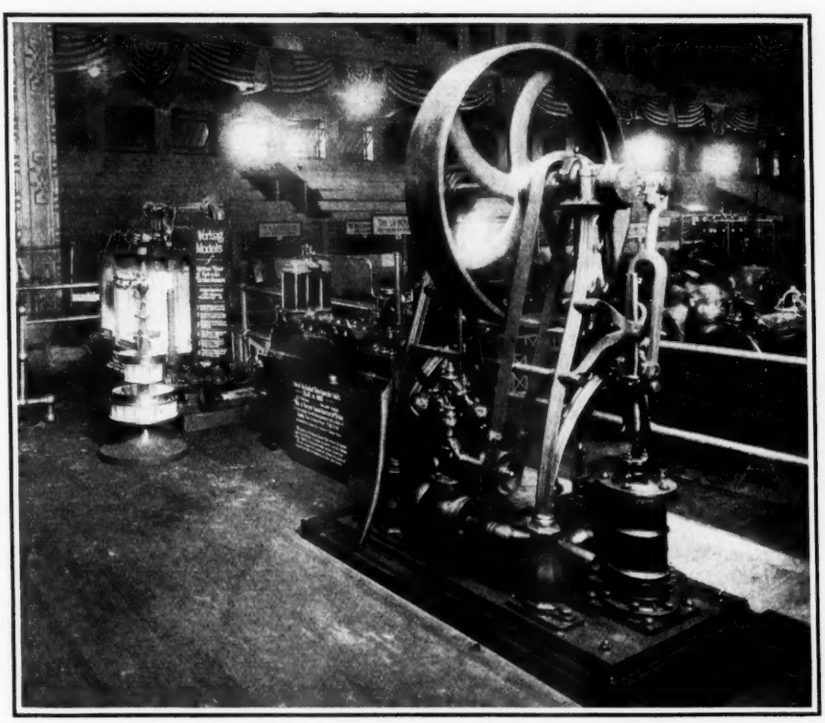


Part of main arena of auditorium—Midwest Power Show

Some historical exhibits, such as Parsons' second commercial turbine driving a bipolar generator, and a primitive vertical engine built in 1853, were in evidence. Immediately beside these exhibits was a glass tank with the necessary equipment and colored liquids to demonstrate the action of the water on impulse and reaction wheels and the flow over the hydraucone regainer.

An interesting feature of the show was a special educational exhibit to which there were a number of contributors. The N.A.S.E. displayed a working model of a Corliss engine. The Milwaukee Vocational School showed a number of products from their shops and a case of apparatus for power-plant testing. The Milwaukee Water Works had on exhibit valves, piping, fittings, etc., to show the results of fifty years of service. An exhibition of products made by metal trade apprentices, of which Milwaukee has 1,003, was of interest. University bulletins, theses and books by the engineering faculty showed what the University of Wisconsin had been doing along educational lines.

During the week two national engineering societies, the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers, held their spring meetings in the city, and the Wisconsin State Association of the N.A.S.E. held its annual convention. Engineers from all sections of the country to the number of 1,500, in addition to the local contingent, were in the city, and many took advantage of the opportunity to visit the show. The attendance at the show would undoubtedly have been larger and better from the exhibitors' standpoint had not the auditorium been about a mile from the A.S.M.E. headquarters.



Some of the historical exhibits at Midwest Power Show

Right to left—Primitive engine built in 1853 to operate the Krug Brewery, Milwaukee. Parsons' second commercial turbo-generator built in 1885.

Stoker Manufacturers Elect Officers

At an executive meeting of the Stoker Manufacturers' Association on May 15, the following officers were elected: President, J. V. Santry; vice-president, R. B. Milden; treasurer, F. H. Daniels. It was decided to have a paid secretary for the association.

Niagara River Power for New York State

The Federal Power Commission, at its meeting May 23, authorized the issuance of a license to the Hydraulic Race Co. and the Lockport-Newsane Mill Owners' Association for the diversion of 275 sec.-ft. daily from the Niagara River and its transportation through the New York State barge canal under the existing agreement with the state authorities. The water is to be used in the power plants of the applicants located along Eighteen Mile Creek.

International Chamber To Study Fuel Conservation

The third biennial meeting of the International Chamber of Commerce, which is to be held at Brussels, June 21-27, will have as one feature on its program, a "Report Suggesting Possible Ways of Conserving the Remaining Solid Fuel Supplies of the United States," by a committee of the American section of the Chamber. The committee that drafted the report was composed of Arthur D. Little, chairman; W. T. Coe, manager of the Consolidation Coal Co., London; C. E. Lesher, former editor of *Coal Age;* Van H. Manning, American Petroleum Institute; George Otis Smith, U. S. Geological Survey; Thomas H. Watkins, Pennsylvania Coal & Coke Corp.; W. DuB. Brookings, Chamber of Commerce.

Radical changes in the use of fuel, necessitated by the approaching exhaustion of the domestic petroleum supplies, are foreseen by the committee. The directions in which developments may come, as outlined tentatively by the committee, are briefly:

"Use of coal at the mines; electrification of railroads, using where possible hydro-electric power; linking together of great central stations; domestic heating from central plants by gas or coke; large use of gas for industrial heating from gas generated at the coal mines; the power in industrial plants to be electrical, from central-power stations linked to general electrical network; much larger development of water power; abandonment of the use of petroleum products for domestic heating, for industrial uses, and for fuel on railroads; increased use of Diesel engines on vessels; development of the oil-shale industry; further improvement in prime movers, especially in the automobile engine; large steam plants to have coal processing plants connected with them, coke being burned as fuel, gas distributed as fuel for domestic and industrial uses, and with full byproduct recovery; exhaust steam to be used for domestic heating as far as possible; abandonment of small gas plants; improved methods of refining petroleum."

New York Central Wants To Use Diesels

The New York Central Railroad Company is seeking to have substituted for the order of the Public Service Commission requiring it to install extensive electrification methods of propelling trains, an order permitting it to adopt methods much less expensive for getting rid of the steam power method. The company has filed with the commission a petition explaining that the development of the internal-combustion engine makes it possible to substitute for steam locomotives a method of propulsion that will eliminate all the objectionable features of the steam railroad at a cost much below that of installing electricity.

The petition states that the new motive power is peculiarly adapted to the needs of the main lines of the Putnam division. It is estimated that installing the three-rail system on one division would cost $9,000,000. The company has been investigating the Diesel engines and it is reported that it has arranged to purchase a number of them.

If the order of the commission is carried out for the installation of electricity, plans for the work must be submitted to the commission by July 1 next, the plans to cover the change of power on the Putnam division and the Saw Mill River road north of the Yonkers branch.

Boiler Manufacturers' Have Good Program

The thirty-seventh annual convention of the American Boiler Manufacturers' Association is being held this week, June 1-3, at the Glen Springs Hotel, Watkins, N. Y. The following papers are on the program:

"Power and Heat for the Small Plant," by David Moffatt Myers, consulting engineer, New York City.

"Terms of Payment and Use of Trade Acceptances," by C. R. D. Meier, Heine Boiler Co.

Address by Charles E. Gorton, chairman, American Uniform Boiler-Law Society.

"Report on Progress of the National Board of Boiler and Pressure Vessel Inspectors," by C. O. Myers, secretary-treasurer and chief of division, Boiler and Inspection and Examiners of Steam Engineers, State of Ohio.

"Sales Methods," by George W. Bach, Union Iron Works.

"Industrial Democracy," by Prof. D. S. Kimball, dean, College of Engineering, Cornell University.

"Advantages of Uniformity under the National Board, Boiler Bootleggers," by Joseph F. Scott, chairman of License and Steam Boiler Inspection Bureau, State of New Jersey, and chairman National Board of Boiler & Pressure Vessel Inspectors.

"Guarantee of Boiler Performance," by William H. Jacobi, Springfield Boiler Co.

"Tensile Strength and Ductility of Steel Boiler Plate and the Tet-Mayer Formula for Figuring Allowable Stresses," by C. L. Huston, Luckens Steel Co. Entertainments of various kinds, including golf tournaments, are scheduled.

A.S.T.M. To Honor Dudley and Marburg

Announcement has been made by the American Society for Testing Materials that the executive committee is to recommend to the society, at the annual meeting next June, that there be established the Charles B. Dudley medal and the Edgar Marburg lecture in honor of the late president and late secretary of the society.

Smoke Prevention Meeting at Grand Rapids

Various aspects of the municipal smoke nuisance and smoke prevention problem will be presented at the annual convention of the Smoke Prevention Association, to be held at the Pantlind Hotel, Grand Rapids, Mich., June 17-20. A special subject will be the relation of oil-burning furnaces and devices to the elimination and abatement of smoke, while one day of the meeting will be assigned to representatives of the railroads. H. B. Meller, chief of the smoke regulation bureau at Pittsburgh, is president of the association; secretary, Frank A. Chambers, chief smoke inspector, 1411 City Hall Square Bldg., Chicago, Illinois.

Research on Gas for Fuel Advocated

The establishment of a national research organization to make gas available to all industrial fuel users was the proposal made here today at the annual spring conference of the American Gas Association by Charles A. Munroe, chairman of the Board of the Laclede Gas Light Co., of St. Louis, and a former president of the association.

As outlined by Mr. Munroe, the objects of the new organization, to be underwritten by the manufactured gas companies of the country, would be to develop efficient gas-burning equipment for all fuel users in industry and enable the gas companies to meet the demand for gas fuel wherever heat is required.

Grand Falls Power Subject of Conference

Asked by the International Waterways Commission to submit a concrete proposition relative to the division of power to be developed at Grand Falls, representatives of Maine and New Brunswick have been in conference recently seeking an agreement, according to press reports. Maine wants a portion of the power to be determined by the relation of the fall of the St. John River while it forms the international boundary to the head of water at Grand Falls. This portion, which would be about one-quarter, Maine says, should be exempt from the Dominion exports tax.

New Brunswick claims the initial development will not affect the international section of the river and disputes Maine's claim to any portion of the power from the initial development. If subsequent developments raise the level of the international river it will recognize Maine's claim to a share of the additional power. The United States Government wants representation on a commission to supervise construction.

M. I. T. Students Design New Rotor Type Tower for Ship

A rotor ship propelled by a new type of revolving tower has been designed by two members of the School of Naval Architecture at Massachusetts Institute of Technology, and will be tested on the Charles River shortly, according to a press announcement.

The ship differs from that invented by Anton Flettner, of Germany, in that the rotor tower is smaller in proportion and revolves at a greater speed.

New York Canal Power Rented for $365,240 Yearly

Under the terms of bids received by the Superintendent of Public Works on May 26, the State of New York will derive a yearly profit of $135,000 from the sale of electric current generated at the state-owned plants at Crescent Dam and Vischer's Ferry on the canalized waters of the Mohawk River. The Cohoes Power & Light Co. bid in the Crescent Dam power at a yearly rental of $174,220 and the Adirondack Power & Light Co. the Vischer Ferry with annual rent of $191,020. The term of the lease is for twenty-five years.

Boiler Explodes in Cleveland Apartment House

One man was killed instantly and two others were seriously injured, according to press reports, when a boiler exploded in a 36-suite apartment building at 2110 Cornell Rd., near the Case School of Applied Science and Western Reserve University, Cleveland, Ohio, on May 22.

The janitor and two plumbers had been repairing a leak in the boiler of the hot-water system, which had been out of order for several days, when the explosion occurred. The details as to the cause of the explosion are not available as we go to press.

Hoover Asks Consumers To Buy Coal Now

Consumers of coal should not forget, Secretary Hoover points out, that there always is great uncertainty in the fall as to the ability of the railroads to handle the peak of the traffic movement. In urging purchases of coal at this time he said:

"Consumers of coal should begin now to lay in their stocks of coal for next winter. The usual summer dip in coal production is on and the mines can take on a much heavier load. The bituminous-coal industry is selling at a loss practically throughout the United States, therefore the consumer cannot complain of prices so far as the mines are concerned. It is always touch and go whether the transportation lines in the fall will be able to handle the crop movement and the winter movement of coal without congestion. If the public will co-operate by buying its coal during warm weather, it will benefit itself and contribute to the stability of the coal industry. For their own interest, to say nothing of the national interest, everybody should lay in their coal now. The only way to stabilize any industry is to try to get continuity of production."

Crawford Avenue Station Officially Opened on May 26

Initial Section of 160,000 Kw. Cost $22,000,000—Designed for an Ultimate Capacity of 750,000 Kw.

ON MAY 26 the Crawford Avenue Station of Commonwealth Edison Co., Chicago, was officially opened. All three of the big units were in operation and the station as a whole spic and span for inspection. Invitations had been issued to a notable list, and from all parts of the country engineers interested in steam generation to the number of 350 responded. A special train had been chartered to convey the guests to the plant and return them after they had had an opportunity to inspect all departments and partake of an excellent luncheon, at which there was a memento for each visitor in the form of a morocco leather bill fold.

After the luncheon the guests were addressed briefly, first by Mayor Dever, who remarked upon the magnitude of the present undertaking and the progressiveness of the organization as a whole and its importance to the community.

Samuel Insull, president of the company, talked informally on the station, giving a few facts and figures to emphasize its magniture, its relation to the system as a whole and the prospects for other large stations similar in character.

In the course of his remarks Mr. Insull paid a glowing tribute to the memory of Frederick Sargent, whose foresight and courage in design had been responsible for a large share of the development in mechanical engineering represented by the new station.

Three Units Installed and Fourth Ordered

In the initial section of the station $22,000,000 has been invested. Three units aggregating 160,000 kw. have been installed and a fourth unit of 75,000 kw. capacity is on order. The engineers are contemplating an ultimate capacity of 750,000 kw., but it was the speaker's expectation that the final total would be nearer 1,000,000 kw. for an expenditure approximating $100,000,000.

By the first three units 930,000 tons of coal per year, or 60 carloads per day, will be converted into more than one billion kilowatt-hours. Other stations of the company bring the total coal consumption for the year to 2,900,000 tons, which might be compared to 160,000 tons per year for city pumping. Based on the fuel consumption of the other large stations, Crawford Avenue will effect a saving annually of 300,000 tons of coal.

Looking to the future, the new station is about the center of the power and light business. At present 54 per cent of the load is north of the canal and river and 46 per cent south, so that the distance from the center of the load now approximates 4½ miles. Other new stations similar in character are to be built, one near the Indiana line and another in Michigan City.

Continuing, Mr. Insull spoke of the 33,000-volt underground ties between stations, the outer power ring around the city and the interconnections through high-voltage transmission systems that make energy available to the four states—Illinois, Indiana, Michigan and Wisconsin.

Just across the road from the station is the byproducts coke plant of the Peoples Gas Light & Coke Co. The two stations had been located in proximity as the day might come, perhaps sooner than anticipated, when they would be working together.

Power Price Was Not Raised During the War

Reference was made to the company policy during the war. It was the one great institution that did not raise its price, and furthermore rates were reduced after the war. This had been made possible by the foresight of the engineering force, the building of large stations in advance and big generating capacity coming in before the higher prices. Coal at comparatively low cost from company owned mines had been another factor. All these things are of great importance to the industrial community in the cost of manufacture, representing in dollars and cents more than to the stockholders of the company. As an evidence that full advantage is being taken, Chicago stands almost at the top of the list in the density of consumption of electrical energy.

In closing, Mr. Insull admitted that it had been an experiment to invite friends to the opening of a station, but the first attempt had been so successful that he was inclined to repeat the performance the next time he started a million-kilowatt station.

The station will be described at greater length in an early issue of *Power*.

High-Pressure 900-Deg. F. Steam Turbine Designed

An order has recently been received by the Erste Bruenner Maschinen-Fabriks - Gesellschaft, of Bruenn, Czechoslovakia, to build a high-pressure, high-temperature turbine for the Witkowitzer Steinkohlengruben (coal mines), Mahr, Ostrau-Privez, Czechoslovakia.

Admission steam pressure at the main throttle will be 100-120 atmospheres or 1,455-1,750 lb. gage and the total steam temperature, 450-500 deg. C. (842-932 deg. F.). The turbine will be designed as tandem-compound condensing, 26,000 hp., 3,000 r.p.m. with four cylinders on one shaft.

This is believed to be the highest pressure specified for a turbine of this size in the United States or Europe, and the temperature exceeds that of any steam plant here or abroad. The turbine is expected to be in operation in about one year.

Sandstone Rapids Gets Automatic Switches

The Sandstone Rapids hydro-electric development of the Northeastern Power Co., located at Sandstone Rapids, Wis., will be equipped with automatic switching apparatus manufactured by the Westinghouse Electric & Manufacturing Co.

This is the third automatic hydro-station on the Northeastern Power Co.'s system, all being controlled by means of the audible type supervisory control which operates over the two-wire telephone line connecting the dispatcher with each generating station. The supervisory control equipment for Sandstone Rapids will permit the starting and stopping of two generators; the locking out of two generators; varying of load on both machines; the opening and closing of high tension feeder breakers; the reading of the head of water and reading of load on both units. It will also provide a trouble alarm and a checker to determine the source of trouble.

A Correction

On page 716 of *Power*, May 5 issue, an error was made in the item "A 15-Mile Water Power Tunnel for Scotland." The name of the engineering firm is C. S. Meik & Buchanan, with whom is associated W. J. E. Binnie. Messrs. Balfour, Betty & Co., Ltd., were the successful contractors and not the engineers as stated.

Obituary

Robert Charles Cole, who for the last twenty-five years has been associated with the Johns-Pratt Co., died May 10 at Hartford, Conn. Born in 1881 at New Haven, he secured his early education in that city, graduating from the Hillhouse High School in 1898 and entering the engineering department of the Johns-Pratt Co. in 1900. He soon became assistant electrical engineer and from 1906 until 1922 held the position of electrical engineer. He then became sales manager of the electrical division, in which position he continued until his death. Mr. Cole was actively interested in the development of the national electrical standard for inclosed fuses. He was a member of the A.I.E.E., Hartford Engineers' Club and other technical organizations.

Personal Mention

Major Paul S. Reinecke, now district engineer at Buffalo and field representative of the Federal Power Commission in that important district, will be designated to take over the duties of assistant chief engineer of the Commission.

W. L. Abbott, chief engineer of power plants of the Commonwealth Edison Co., Chicago, left the city recently for a two months' vacation, his objective being San Francisco by way of New York and the water route on the Steamship "Kroonland" with the anticipation of arriving in San Francisco on June 8 in time to attend the annual convention of the N.E.L.A.

Coming Conventions

American Association for the Advancement of Science, Burton E. Livingston, Smithsonian Bldg., Washington, D. C. Eightieth annual meeting at Portland, Ore., June 17-20.

American Boiler Mfg. Association, H. N. Covell, 7 East 19th Ave., Brooklyn, N. Y. Meeting at Glen Spring Hotel, Watkins, N. Y., June 1-3.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, Chalfonte-Haddon Hall, June 22-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Annual convention at Saratoga Springs, June 22-26. Pacific Coast convention, Seattle, Wash., Sept. 15-17.

American Order of Steam Engineers. W. S. Wetzler, 753 N. 44th St., Philadelphia, Pa. Annual convention at Moose Hall, 1314 N. Broad St., Philadelphia, Pa., June 8-12.

American Society of Heating & Ventilating Engineers. F. C. Houghten, 29 West 39th St., New York City. Semi-annual meeting at Traymore Hotel, Atlantic City, June 15-17.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Regional meeting at Portland, Ore., June 22-25.

Canadian Association of Stationary Engineers. G. A. Brown, Major St., Toronto, Ont. Convention at Windsor, June 22-25.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Illinois Association at Decatur,** Olaf Jacobsen, 837 Lake Side Place, Chicago. June 3-5. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at McAlpin Hotel, New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **Iowa State Association** at Ottumwa, June 16-18. F. L. Stocker, 127 S. Elm St., Ottumwa, Iowa. **New England States Association** at Worcester, Mass., July 9-11, formerly announced July 10-12. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Michigan Association** at Muskegon, July 15-17. Charles Unterreiner, 5522 Underwood Ave., Detroit, Mich. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National Electric Light Association. M. H. Aylesworth. 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

New England Water Works Association, Frank J. Gifford, Dedham, Mass., sec. Convention to be held aboard "Richelieu," en route Montreal to Quebec, etc., Sept. 8-11. For details apply to George E. Marsters, Inc., 248 Washington St., Boston, Mass.

Smoke Prevention Association—Frank A. Chambers, 1411 City Hall Sq. Bldg., Chicago, Ill. Nineteenth annual convention at Hotel Pantlind, Grand Rapids, Mich., June 17-20.

Society of Automotive Engineers, Inc. C. F. Clarkson, 29 West 39th St., New York City. Convention at Greenbrier Hotel, White Sulphur Springs, June 15-19.

Society for the Promotion of Engineering Education. F. L. Bishop, University of Pittsburgh, Pa. Meeting at Union College, Schenectady, N. Y., June 17-20.

R. J. S. Pigott, mechanical engineer with Stevens & Wood, New York City, has accepted a position with the Public Service Production Co., of New Jersey, effective June 1.

O. P. Hood, mechanical engineer of the United States Bureau of Mines, is on his way to Alaska for a two-months' inspection trip of the Alaskan coal fields and the Bureau's local stations.

Dr. Michael I. Pupin, president of the American Association for the Advancement of Science and professor of electro-mechanics at Columbia University, New York City, will give the commencement address this year at the Carnegie Institute of Technology, Pittsburgh, Pa.

L. W. Heller has resigned as general superintendent of power stations of the Duquesne Light Co. to join the engineering staff of the Bailey Meter Co., of Cleveland, in the capacity of general engineer. In the May 19 issue it was erronously stated that Mr. Heller was to be general manager of the company instead of general engineer.

Roswell E. Pfohl and **Thomas S. McLaughlin** announce the establishment of the new firm of Pfohl & McLaughlin, Inc., architects and engineers, at 830 Walbridge Bldg., Buffalo, N. Y. Mr. Pfohl was formerly chief engineer for Moran, Maurice & Proctor, consulting engineers, New York City, and Mr. McLaughlin has been practicing architecture for the past nine years in Providence, R. I. Both are M.I.T. men.

Business Notes

The Condit Electrical Manufacturing Co., 838 Summer St., South Boston, Mass., announces that it has purchased land and buildings at Hyde Park, Mass., which will be utilized for its business in addition to its main offices in South Boston.

The Sharpless Specialty Company, of Philadelphia, Pa., announces that it has established a new Pacific Coast office at 688 Howard St., San Francisco, Calif., under the name of the Sharpless Specialty Company of California. This office and the Pacific Coast territory will be in charge of L. A. Taylor.

The Conveyors Corporation of America, 326 West Madison St., Chicago, Ill., announces that its mono-rail cable conveyor will be handled in Ohio by H. P. Rodgers, Leader Bldg., Cleveland, Ohio., who will have associated with him, Eugene Smith, formerly with the Galion Iron Works; E. A. Grimmer, formerly with the Elliott Co., has joined the sales organization of the Lathrop-Trotter Co., the company's representative in Cincinnati.

The Roller-Smith Co., manufacturer of electrical instruments and circuit breakers 233 Broadway, New York City, announces the appointment of The Detweiler-Bell Co., 101 Milk St., Boston, Mass., and 152 Temple St., New Haven, Conn., as its representative in the states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut and Rhode Island, succeeding Walter W. Gaskill, who has been representing the company in the New England territory for several years.

The Austin Company, engineers and builders, 16112 Euclid Ave., Cleveland, Ohio, announces the removal of its New York Office to the Equitable Bldg., 120 Broadway, which is in charge of J. K. Gannett, district manager.

The Dean Hill Pump Co., Anderson, Ind., announces the following appointments: The Stewart Machinery Co., 411 Buder Bldg., St. Louis, Mo., as its local dealer in the St. Louis territory; E. C. Werner, Woodlawn, Cincinnati, Ohio, as representative in the Cincinnati district.

The McClave Brooks Co., Scranton, Pa., announces that it has recently reopened its Boston sales office at the old address, 261 Franklin St., with J. C. Stewart, manager, in charge and that the Boston territory will consist of all the New England States; that the New York office has been moved from 461 Eighth Ave., to 1440 Broadway; that E. D. Giberson & Co., Inc., 40 Rector St., New York City, will be the company's representative in the Island of Cuba, with address in Cuba at Banco de Canada 401, Havana, Cuba.

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., announces the establishment of branch offices at Tampa, Florida, with W. L. Southwell, formerly branch manager at Atlanta, in charge and at Chattanooga, Tenn., with J. C. Boesch as branch manager. Changes in personnel at the Atlanta office are: W. W. Ballew will be branch manager for Georgia; J. G. Simpson will be manager of the central division and for the Atlanta territory; T. N. Lide, manager of the industrial division in charge of the marine division, and R. H. Atkinson, manager of the merchandising division.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	May 25, 1925
Pool 1	New York	$2.40@$2.70
Smokeless	Boston	1.54
Clearfield	Boston	1.70@ 2.00
Somerset	Boston	1.85@ 2.10
Kanawha	Columbus	1.35@ 1.50
Hocking	Columbus	1.40@ 1.60
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.50@ 1.60
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.15@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	$2.00@$2.50
Buckwheat No. 1.	Philadelphia	2.25@ 2.75
Birdseye	New York	1.60@ 1.85

FUEL OIL

New York—May 28, light oil, tank-car lots; 28@34 deg. Baumé, 5¼c. per gal.; 36@40 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis—May 26, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75 per bbl.; 28@30 deg., $1.80 per bbl.; 30@32 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4.7c. per gal.; 38@40 deg., 5½c. per gal.

Pittsburgh—May 18, f.o.b. local refinery; 30@34 deg. fuel oil, 4¾c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.

Dallas—May 23, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

Philadelphia—May 21, 28@30 deg., $2.21@$2.273 per bbl.; 18@22 deg., $1.90@$1.963; 13@16 deg., $1.785@ $1.85 per bbl.

Boston—May 25, tank-car lots, f.o.b. heavy oil, 12@14 deg., Baumé, 4⅝c. per gal. light oil, 28@32 deg. Baumé, 5¾c. per gal.

Cincinnati—May 26, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5¼c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5⅝c. per gal.

Trade Catalogs

Storage Tanks — Hahn Engineering Co., Twentieth St. and Indiana Ave., Philadelphia, Pa. A catalog of octagonal and semi-octagonal sectional cast-iron storage tanks for ashes, coal, coke, sand and gravel has recently been issued. Illustrations show plan, elevation and details of tanks.

Rubber — Goodyear Tire & Rubber Co., Inc., Akron, Ohio. "Handbook of Goodyear Mechanical Rubber Goods" is a neat catalog covering rubber belts, hose, packing, valves, mats and matting. Useful tables on sizes of belts and instructions on figuring transmissions, and also on circumferences and areas of circles, are given.

Floats—Frank Engelhard & Sons, 100 Franklin St., Springfield, Mass. Catalog descriptive of "Hercules" seamless copper ball floats for service in corrosive waters and column floats for boiler feeders in any size and for any working pressure up to 350 lb. steam, has just been received. A table of standard sizes, weights and buoyancies is given and also a list of air chambers for steam pumps.

New Plant Construction

Ark., Fayetteville—Phillips Box Co., 20 East Center St., will build an addition to box factory on East Center St., by day labor. Estimated cost $75,000. Power equipment will be purchased. Private plans.

Ark., Pine Bluff — Arkansas Light and Power Co. is having preliminary plans prepared for the construction of a 100,000 hp. hydro electric power plant, dam, etc., at Colbert Shoals. Ford Bacon & Davis, 115 Broadway, New York, are engineers.

Calif., Los Angeles—J. Toplitzky, et. al., H. W. Hillman Bldg., is having plans prepared for the construction of a 13 story office building, including steam heating system and elevators, on East Side Spring St. between 6th and 7th Sts. Estimated cost $1,000,000. Schultze & Weaver, Pacific Mutual Bldg., are architects.

Calif., Manteca—South San Joaquin Irrigation Dist., and Oakdale Irrigation Dist., Oakdale, voted $2,200,000 bonds for the construction of Melones Dam. Plans include pumping plant, etc. A. J. Wiley, Boise, Idaho, is consulting engineer.

Calif., Orange—City plans an election to vote $1,200,000 bonds for the construction of improvements to waterworks system, including pumping plant, distribution system, etc.

Calif., San Francisco—Huntington Community Inc., c/o Weeks & Day, 315 Montgomery St., Archts., is having plans prepared for the construction of a 15 story apartment near California and Taylor Sts. Estimated cost $1,000,000.

D. C., Washington—Ballinger Co. and J. P. Richter, 12th and Chestnut Sts., Archts., will receive bids until June 4th for the construction of a 4 story, hospital building, including power room and equipment, for the Sibley Memorial Hospital, Pierce and North Capitol Sts.

D. C., Washington—J. J. Schwartz has had plans prepared for the construction of a 12 story hotel, at 13th and E Sts., including vapor heating system. Milburn, Heister & Co., Union Savings Bank Bldg., are architects.

Fla., Bartow—City, J. E. Childs, Mgr., plans the construction of an electric light plant. Estimated cost to exceed $40,000. Power equipment will be purchased. E. V. Camp, 1 North Marland St., Atlanta, Ga., is engineer.

Fla., Brandenton — City plans the construction of water and light improvements. E. V. Camp and Associates, Moreland St. and DeKalb Ave., Atlanta, Ga., are engineers.

Fla., Cedar Keys—Cedar Keys Light and Power Co. plans the construction of an additional 100 kw. light unit and 40 ton ice plant. Capitol stock will be increased $50,000.

Fla., Clearwater—Lloyd, White & Skinner Co. is having plans prepared for the construction of a hotel at Clearwater Beach Island. Estimated cost $700,000. R. E. Smallwood is architect.

Fla., Haines City—Development Corporation of Florida, R. Polk, Pres., is having plans prepared for the construction of a 9 story hotel at Hinson Ave. Estimated cost $500,000. Wallick & Rich, 308 Hume-Mansur, Indianapolis, Ind., and Winter Park, Fla., are architects.

Fla., Miami—East Coast Enterprise, Inc., T. W. Palmer, Pres., plans the construction of a 17 story hotel at southwest cor. North Bay Shore Drive. Estimated cost $2,000,000.

Fla., Miami—First Trust & Savings Bank, awarded contract for the construction of a 15 story bank and office building, to G. A. Fuller, 949 Broadway, New York. Steam heating system will be installed.

Fla., Sarasota—Clas, Shepherd & Clas, 445 Milwaukee St., Milwaukee, Wis., Archts., are preparing preliminary plans for the construction of a 300 room hotel, here. Estimated cost $1,000,000. Owners' name withheld.

Fla., Tallahasse—West Florida Power Co. plans the construction of a power house and dam, across the Oclochne River, near here. Estimated cost $750,000. G. A. Winthrop is resident engineer. Mees & Mees, Kinney Bldg., Charlotte, N. C., are consulting engineers.

Fla., Wauchula — City Council, W. D. Carlbow, Mayor, plans the construction of an electric light plant annex. Estimated cost $40,000.

Ga., Augusta—Augusta Aiken Railway & Electric Corporation, Lamar Bldg., has had plans prepared for the construction of two additional units to power plant, 2250 hp. each, on Stevens Creek. Estimated cost $360,000. J. G. White Engineering Co., 43 Exchange Place, New York, is engineer.

Ga., Atlanta — Chamber of Commerce, Pryor St. and Auburn Ave., plans the construction of a 12 story office building, on the present site. Estimated cost $600,000. W. R. C. Smith is president.

Ill., Wheaton—Wheaton Sanitary Dist., Du Page County, City Hall, F. D. Ewall, Clk. is taking bids until June 16 for the construction of a sewage disposal plant, including tank and pumping station, etc. Alvord, Burdick & Howson, 8 South Dearborn St., Chicago, are consulting engineers.

Ia., Hampton—City, A. W. Wolf, Mayor, plans an election to vote $11,000 bonds for sinking well including pumping equipment.

Kas., Greensburg—City, W. L. Fleener, Jr., Clk., plans an election June 8th to vote $50,000 bonds for improvements and extension to electric light plant.

Kas., Larned—State is having plans prepared for the construction of a power plant, including boilers and boiler equipment. Estimated cost $60,000. C. D. Cuthbert, State House, Topeka, is architect.

Md., Baltimore—Mayor and City Council, City Hall, rejected bids for the construction of a pumping station, filter building, etc., on Montebello Ave. V. B. Siems, City Hall, is engineer.

Md., Highlandtown (Baltimore P.O.)—A. Weiskittel & Sons Co., Lombard and 12th Sts., H. C. Weiskittel, Pres., will rebuild part of plant, including boiler and engine rooms, destroyed by fire. Work will be done by day labor. Estimated cost $150,000.

Mass., Boston — City Hospital Dept. awarded contract for the construction of a 9 story hospital at Albany and East Concord Sts., to J. Bowen Co., 184 Dudley St., Roxbury.

Mass., Boston—C. H. Blackall, 20 Beacon St., plans the construction of a 17 story hotel on Tremont St. Estimated cost $2,000,000. Blackall, Clapp & Whittemore, 20 Beacon St., are architects.

Mass., Boston—E. N. Wyner, 18 Tremont St., plans the construction of a 10 story hotel at Newbury and Arlington Sts. Estimated cost $2,000,000. Architect not selected.

Mass., Cambridge (Boston P. O.)—E. N. Wyner, 18 Tremont St., Boston, is having plans revised for the construction of a 10 story apartment at Harvard Sq., here. Estimated cost $1,000,000. G. N. Jacobs, 4 Park St., Boston, is architect.

Mass., Springfield — William Lay, Inc., Bridge St., plans the construction of an apartment at Main and Plainfield Sts. Estimated cost $1,000,000. Architect not selected.

Mass., Springfield—Massachusetts Mutual Life Insurance Co., 500 Main St., awarded contract for the construction of a 4 story office building, 3 story power house and storehouse, to Turner Construction Co., 178 Tremont St., Boston.

Mich., Detroit — Bd. of Education, 1354 Broadway Ave., plans the construction of first unit of a medical college at St. Antoine St., also detached power plant. Estimated cost $560,000. Donaldson & Meyer, 1314 Penobscot Bldg., are architects.

Mich., Detroit—Detroit Railway & Harbor Terminals Co., Buhl Bldg., awarded contract for the construction of a 200 x 600 ft. warehouse as first unit of freight terminal on Jefferson Ave. West, to Parklap Construction Co., 84 Pine St., New York. Plant will provide 200,000 sq.ft. of cold storage space.

Mich., Detroit — The Maccabees, A. W. Frye, Supreme Commander, Woodward and Putnam Aves., plans the construction of a 10 story office building, including steam heating boiler and equipment, at Woodward Ave. Estimated cost $2,500,000. A. Kahn, 1000 Marquette Bldg., is architect.

Mich., Detroit — Wayne Lodge Pythian Castle Assn., c/o Weston & Ellington, 1507 Stroh Bldg., Archts., awarded contract for the construction of a 11 story lodge and hotel building, including steam heating system, at Cass and Temple Aves., to Otto Misch Co., 159 East Columbia St. Estimated cost $1,000,000.

Mich., Jackson — R. W. Reynolds, 176 Michigan Ave., plans the construction of a 14 story office building, including steam heating system, on West Michigan Ave. A. Kahn, 1000 Marquette Bldg., is architect.

Minn., Duluth — Duluth Water & Light Dept., D. A. Reed, Mgr., plans the construction of waterworks improvements, including reservoirs, mains, etc. A booster pump will be installed in the Park Point District.

Minn., Minneapolis — M. T. Baker, 517 Marquette Ave., awarded general contract for the construction of a 12 story office building to J. Leck Co., 211 South 11th St. Estimated cost $1,000,000. Steam heating system will be installed.

Minn., St. Paul—Ramsey County, G. J. Ries, Auditor, will soon take bids for deep well pumping equipment. Bids for sinking deep wells will be closed June 1.

Mo., St. Louis—Skouras Bros. Enterprises, Grand Central Bldg., awarded contract for the construction of a 22 story office and theatre building at 7th and Locust Sts., to Boaz-Kief Construction Co., 4030 Chouteau Ave. Estimated cost $2,300,000.

N. J., Asbury Park—T. H. Beringer, Jr., Deal, is having plans prepared for the construction of a 7 story hotel on Ocean Ave., here. Estimated cost $1,000,000. Warren & Wetmore, 16 East 47th St., New York, are architects.

N. J., Montclair—Bd. of Commissioners, H. Trippett, Clk., will receive bids until June 9 for the construction of an emergency pumping station, also for the furnishing and installing of 2 motor driven centrifugal sewage pumping units, electric control apparatus and auxiliary equipment.

N. J., Newark—Lincoln Building Corporation, c/o F. Grad, Broad St., Archt. and Engr., plans the construction of a 12 story office building, including steam heating system, on Broad St. Estimated cost $1,000,000.

N. Y., New York—A. Heckscher, 50 East 42nd St., plans the construction of a 15 story office building, at Park Ave. and 56th St. Estimated cost $3,000,000.

N. Y., New York—M. N. Natason, 522 5th Ave., and Mandelbaum & Levine, 160 Broadway, plan the construction of a 30 story office building, at 5th Ave. and 44th Sts. Estimated cost $6,000,000. H. C. Severance, 36 West 44th St., is architect.

N. Y., New York—New York Edison Co., 15th St. and Irving Place, awarded general contract for first unit of power plant, 120,000 kw. ultimate capacity 700,000 kw. on 14th St. and East River to Kenn-Well Construction Co., 45 East 17th St. Engineers estimate $12,000,000. Total ultimate cost $50,000,000. T. E. Murray Inc., 55 Duane St., is consulting engineer.

N. Y., Queens—State Hospital Commission, Capitol, Albany, will receive bids about June 1st for the construction of a group of hospital buildings including a cold storage plant for the Creedmore Division, Brooklyn State Hospital, here. S. W. Jones, Capitol, Albany, is state architect.

O., Cleveland—City, D. Blossom, Director of Public Welfare, plans the construction of hospital on Scranton Road. Estimated cost $1,000,000. H. Kregelins, City Hall, is engineer.

O., Cincinnati—G. A. Grey Co., Gest and Depots Sts., H. Marx, Pres., awarded contract for the construction of a new plant, including boiler house, etc., with equipment to The Austin Co., 16112 Euclid Ave., Cleveland.

O., Dayton—Third National Bank, 21 East 3rd St., will soon award contract for the construction of a 12½-story bank and office building. Schench & Williams, Mutual Home Bldg., are architects.

O., Lima — Lima Trust Co., Market and Public Sq., plans the construction of a 10 story bank and office building. Estimated cost $1,000,000. Architect and engineer not announced.

O., Lima—Old National Bank, Main and High Sts., plans the construction of a 12 story bank and office building. Estimated cost $1,000,000. Architect and engineer not announced.

Okla., Cherokee — City voted $35,000 bonds for the purchase of a 400 hp. Diesel engine generator unit, for electric light plant. A. J. Titus is Mayor.

Okla., Eufaula—City, R. L. Carter, Clk., will have preliminary plans prepared for the construction of a waterworks system, including pumping machinery, capacity 500,000 g.p.d., etc. Estimated cost $25,000.

Okla., Frederick — City plans the construction of addition to power plant including equipment. Estimated cost $160,000.

Okla., Okmulgee — City plans the construction of a new water supply including pumping equipment, etc. Estimated cost $1,000,000. Holway Engineering Co., Wright Bldg., Tulsa, is engineer.

Pa., East Pittsburgh—B. H. Prack, Martin Bldg., Pittsburgh, Archt., will receive bids about June 2nd for the construction of an 11 story office building, here, for Westinghouse Electric & Mfg. Co.

Pa., Erie—Erie Trust Co. has had plans prepared for the construction of a 20 story bank and office building, here. Dennison & Hirons, 288 Lexington Ave., New York, are architects.

Pa., Fox Chase (Philadelphia P. O.)—Society of Friends, 15th and Race Sts., Philadelphia, plans the construction of 2 buildings, for the Jeannes Memorial Hospital and Infirmary, at Stapley Farms, near here. Estimated cost $1,000,000. Heacock and Hokanson, 1211 Chestnut St., Philadelphia, are architects.

Pa., Philadelphia — Emergency Aid of Pennsylvania, 221 South 18th St., Mrs. J. W. Martin, Chmn., plans the construction of a hotel, club and office building at 20th and Sansom Sts. Estimated cost $850,000. A. L. Hermon, 3 West 29th St., New York, is architect.

Pa., Philadelphia—Public Baths Assn. of Philadelphia, 718 Wood St., plans the construction of a 2 story bath house, including a 7 hp. steam engine, automatic sump pumps, boilers, etc., at Kensington and Hazzard Sts.

Pa., Red Lion — Red Lion Water Co. awarded contract for the construction of a pumping station, filter plant, reservoir, dam, etc., to Gannett, Seelye & Fleming, Engineers, Inc., 1 North Market Sq., Harrisburg. Estimated cost $250,000.

S. D., Rockham—City will receive bids until June 12th for a 4 x 6 ft. triplex pump, 325 gal. centrifugal pump, 20 hp. gas engine, mains, tank, etc. Dakota Engineering Co., Mitchell, is engineer.

Tex., Bossier—City, J. M. Birdwell, Clk., awarded contract for the construction of water works and sewer systems, including a pumping station to Janes Contracting Co., South West Life Bldg., Dallas. Estimated cost $140,000.

Tex., Carlsbad — State is having plans prepared for the construction of addition to power plant for Tubercular Sanitorium. Estimated cost $50,000. Phelps & DeWees, Gunter Bldg., San Antonio, are engineers. Equipment will be purchased.

Tex., Cuero—City plans an election soon to vote $28,000 bonds for the construction of mains, pumping equipment, etc.

Tex., Dallas — Dallas Cotton Exchange, 1501½ Commerce St., R. L. Dixon, Chrn. of Building Comn., plans the construction of a 16 story office building, at Harwood and San Jacinto Sts. Estimated cost $1,500,000. Architect not selected.

Tex., Dallas — M. G. James, Secy., awarded contract for the construction of a sewage pumping plant to Klein Bros., 8223 Walton St. Estimated cost $35,000.

Tex., Nordheim — City, E. December, Mayor, plans an election to vote $30,000 bonds for waterworks improvements, including pumping equipment, etc. Terrell Bartlett Engineers, 612 Calcasieu Bldg., San Antonio, are engineers.

Tex., O'Donnell—City Commission plans an election to vote $40,000 bonds for construction of a waterworks system, including pumping equipment, etc. Devlin Engineering Co., 119 Central Bldg., Amarillo, is engineer.

Tex., Port Arthur—Kansas City Southern Railway, Kansas City, Mo., is having plans prepared for the construction of a power plant, etc., here. Estimated cost $1,250,000. A. N. Reece, Southern Bldg., Kansas City, Mo., is chief engineer.

Tex., San Antonio—State is having plans prepared for the construction of a waterworks system, including a well, pumping equipment, etc., at Southwestern Insane Asylum. Estimated cost $30,000. Phelps & DeWees, Gunter Bldg., are engineers.

Tex., Temple—P. L. Downs, First National Bank, and J. C. Mitchell, Manager, Temple Ice & Refrigerating Co., plan the construction of an ice, refrigeration and cold storage plant, on Ave. A, between 7th and 9th Sts. Estimated cost $150,000. Private plans.

Tex., Wharton — City plans an election soon to vote $50,000 bonds for waterworks improvements, including pumping equipment, etc. Terrell Bartlett Engineers, 612 Calcasieu Bldg., San Antonio, are engineers.

W. Va., Huntington—J. M. McCoach & Son, 1301 7th Ave., awarded contract for the construction of a 6 story cold storage and refrigerating plant, to C. W. Hancock & Son, Krise Bldg., Lynchburg, Va. Estimated cost $175,000. Private plans.

Wis., Deerfield — Village, E. Helmicks, Clk., is having plans prepared for addition to water supply system, including a 300 g.p.m. centrifugal engine driven pump, 50,000 gal. reservoir, etc. Estimated cost $8,000. W. G. Kirchoffer, 22 North Carroll St., Madison, is engineer.

Wis., Green Bay — Wisconsin Public Service Corporation, 559 Marshall St., Milwaukee, plans the construction of a steam power plant, here. Engineer not selected. Complete equipment will be purchased.

Wis., Milwaukee—Brumder Estate, 105 Wells St., awarded contract for the construction of a 3 story, 52 x 150 ft. newspaper plant, on 7th St. here. Estimated cost $100,000. Electric motors, etc. will be purchased.

Wis., Milwaukee — Hotel Astor Co., Juneau Ave. and Marshall St., awarded contract for the construction of an 8 story hotel addition to S. M. Siesel Co., 160 Ogden Ave. Estimated cost $700,000.

Wis., Racine—H. Nelson, Comnr. of Public Works, plans the installation of an additional generating unit for street lighting. Alvord, Burdick & Howson, 8 South Dearborn St., Chicago, Ill., are engineers.

Wis., Stoughton—Martin Luther Orphan Home, N. A. Stubkjaer, Supt., plans the construction of a heating plant. Estimated cost $40,000. Complete equipment will be purchased. Engineer not selected.

B. C., Sapperton—Frye & Co., 9th, South and Walker Sts., Seattle, Wash., is having plans prepared for the construction of a cold storage plant addition, here. Estimated cost $500,000. Company engineers in charge.